# Energy Statement

## Harrods Wharf


Client: Jamie Waller

Author: Sophie Beesley


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## Revision History

| Version | Date Issued | Issued by | QA Check |
|---|---|---|---|
| **1** | 13.01.2021 | Sophie Beesley | Michael Woodbridge |
| **2** | 22.01.2021 | Sophie Beesley | Michael Woodbridge |

**About Environmental Economics**

Our team of experienced consultants specialise in construction and building energy. We have qualifications in sustainability, energy, engineering, building physics and construction as well as environmental, quality management and auditing.

Over the last decade, we have provided assessments and consultancy for some of the largest UK house builders, including Barratt Developments, David Wilson Homes, Bellway Homes, Abbey New Homes and Davidsons. We develop flexible, practical, cost-effective specifications for our clients through identifying solutions and delivering design advice. This includes the following disciplines:

- *Overheating Analysis (dynamic thermal modelling)*
- *Daylighting / Sunlight Simulations*
- *Energy Reports*
- *Compliance assessments and advice covering*
    - *Part L (SAP)*
    - *Part F (ventilation)*
    - *Part G (water)*
- *BREEAM*
- *SBEM (existing and new build)*
- *Minimum Energy Efficiency Standards (MEES)*
- *Thermal Bridging (Psi value calculations)*

# Contents

# 1. Executive Summary

1.1.1. This Energy Assessment has been prepared by Environmental Economics Ltd to support a planning application for a proposed development on Harrods Wharf, in The London Borough of Richmond upon Thames.

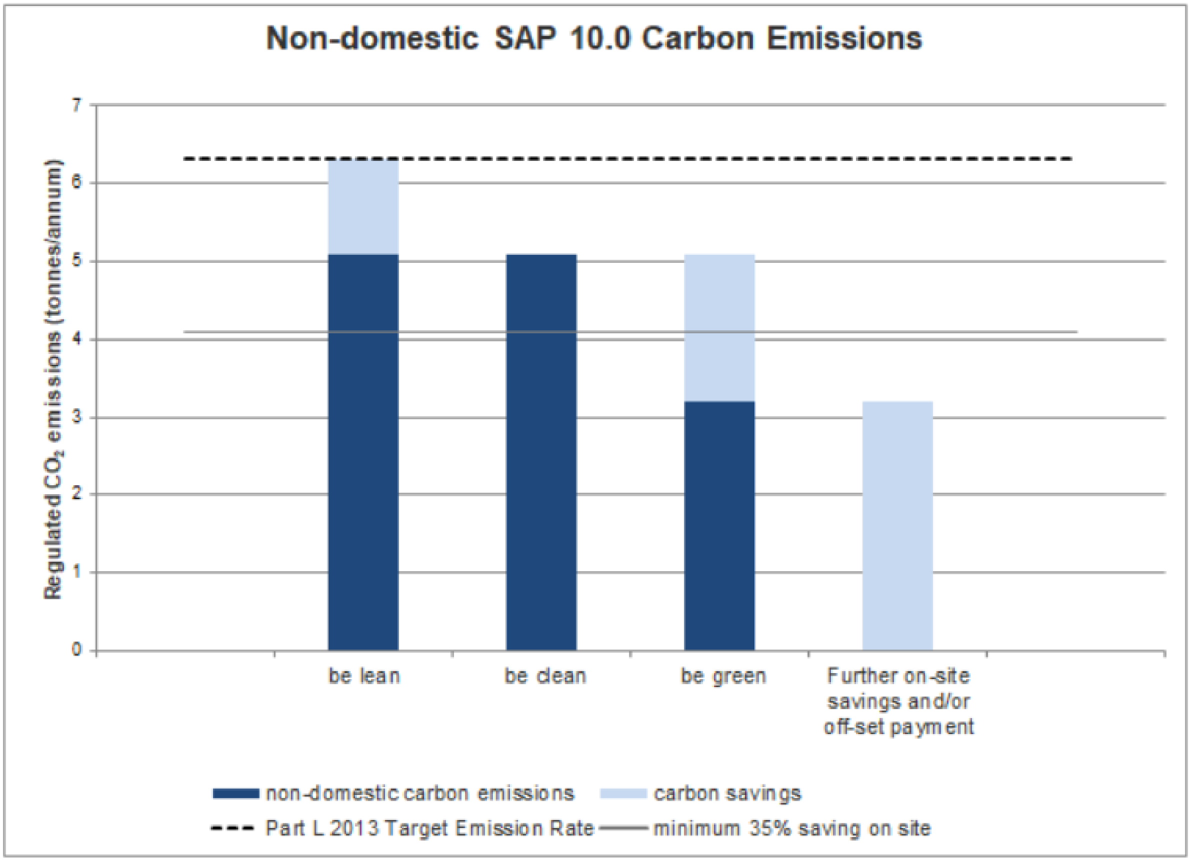
1.1.2. The Assessment is presented with reference to the requirements set out in the London Plan 2016 (LP2016), Intend to Publish London Plan 2020 (LP2020) and the London Borough of Richmond upon Thames, Sustainable Construction Checklist.

1.1.3. The main objective of the assessment is to indicate the performance of the development in relation to Policy SI 2, which sets an objective of reducing carbon emissions resulting from regulated energy use by 35% in comparison to the 2013 Building Regulations. No offset payment is required for minor developments, nor is the zero carbon target.

1.1.4. As per the recommendations set out in the sustainable construction checklist, this report uses the updated SAP 10 emission factors to demonstrate performance against planning policy targets. See figure 1.

1.1.5. The strategy has been designed as a combined approach for both buildings. As a result all figures shown are applicable to the whole site.

**Figure 1 – Non-domestic Carbon Emissions from the Energy Hierarchy**




1.1.6. The following table summarises the reductions achieved at each stage of the energy hierarchy.

**Table 1 –Non-domestic carbon emissions after each stage of the Energy Hierarchy**

| | Carbon Dioxide Emissions for non-domestic buildings (Tonnes $CO_2$ per annum) | |
|---|---|---|
| | Regulated | Unregulated |
| Baseline: Part L 2013 of the Building Regulations Compliant Development | 6.3 | 9.0 |
| After energy demand reduction (be lean) | 5.1 | 9.0 |
| After heat network connection (be clean) | 5.1 | 9.0 |
| After renewable energy (be green) | 3.2 | 9.0 |

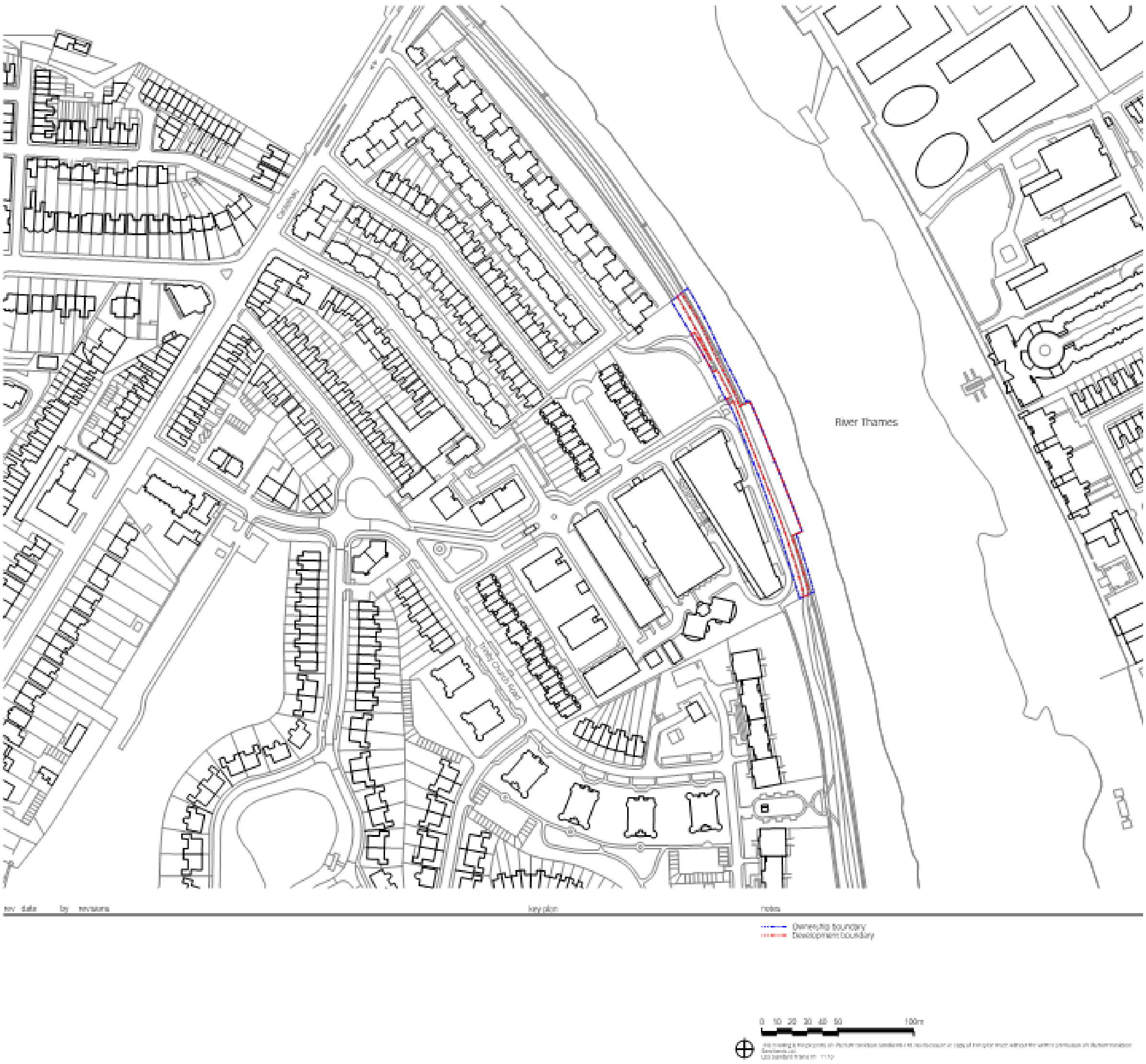
**Table 2 – Non-domestic regulated carbon savings from each stage of the Energy Hierarchy**

| | Regulated non-domestic carbon dioxide savings | |
|---|---|---|
| | (Tonnes $CO_2$ per annum) | (%) |
| Be lean: savings from energy demand reduction | 1.2 | 19% |
| Be clean: savings from heat network | 0.0 | 0% |
| Be green: savings from renewable energy | 1.9 | 30% |
| **Total Cumulative Savings** | **3.1** | **49%** |

# 2. Introduction

2.1.1. The site is located in the London Borough of Richmond upon Thames. The immediate vicinity is shown in Figure 2 below, with the red outline indicating the development area.

**Figure 2 – Site Location Plan**



2.1.2. The client proposes 2 single storey units with 138m$^2$ GEA floor space each, under Sui Generis. For the purpose of this assessment, the units have been assessed under classes A1-A5.

2.1.3. The proposed development is classified as a "Minor Development" and therefore a detailed energy assessment has been carried out in compliance with the relevant applicable policies.

2.1.4. This report undertakes an energy demand analysis using a UK Government accredited software tools to model the non-domestic space. The energy demand is converted into carbon emissions within the software tool, with a separate spreadsheet – issued by the GLA –being used to calculate the corresponding SAP10 figures.

2.1.5. As required by the Sustainable Construction Checklist the incremental effects of each stage of the energy hierarchy are identified and tabulated.

# 3. Planning Requirements

3.1.1. The development is required to comply with the technical requirements set out on the LP2020. The individual criteria are set out below (taken directly from LP2020 SI 2):

*Policy SI 2 Minimising greenhouse gas emissions*

*A. Major development should be net zero-carbon. This means reducing greenhouse gas emissions in operation and minimising both annual and peak energy demand in accordance with the following energy hierarchy:*

*1) be lean: use less energy and manage demand during operation*

*2) be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly*

*3) be green: maximise opportunities for renewable energy by producing, storing and using renewable energy on-site*

*4) be seen: monitor, verify and report on energy performance.*

*B. Major development proposals should include a detailed energy strategy to demonstrate how the zero-carbon target will be met within the framework of the energy hierarchy.*

*C. A minimum on-site reduction of at least 35 per cent beyond Building Regulations is required for major development. Residential development should achieve 10 per cent, and non-residential development should achieve 15 per cent through energy efficiency measures. Where it is clearly demonstrated that the zero-carbon target cannot be fully achieved on-site, any shortfall should be provided, in agreement with the borough, either:*

*1) through a cash in lieu contribution to the borough's carbon offset fund, or*

*2) off-site provided that an alternative proposal is identified and delivery is certain.*

*D Boroughs must establish and administer a carbon offset fund. Offset fund payments must be ring-fenced to implement projects that deliver carbon reductions. The operation of offset funds should be monitored and reported on annually.*

*E Major development proposals should calculate and minimise carbon emissions from any other part of the development, including plant or equipment that are not covered by Building Regulations, i.e. unregulated emissions.*

*F Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.*

3.1.2. The development is expected to meet the following requirements for a minor development, as stated in the Sustainable Construction Checklist. The applicable policy has been highlighted in green.

| ***Type of development*** | ***Standards to be met*** |
|---|---|
| *Major residential development (10 units or more)* | *• Zero carbon standards<br>• Submit energy statement<br>• National water standards - 110 l/p/d<br>• Submit Sustainable Construction Checklist* |
| *All development that results in a new residential dwelling or unit including conversions, reversions, change of use and extensions that create one or more new dwellings* | *• 35% reduction in CO2 emissions over Building Regulations (2013)<br>• Submit energy statement<br>• National water standards - 110 l/p/d<br>• Submit Sustainable Construction Checklist* |
| *Change of use or conversion to residential and residential extensions which do not result in a new dwelling* | *• BREEAM Domestic Refurbishment 'Excellent' (where feasible)<br>• Submit Sustainable Construction Checklist* |
| *New non-residential buildings, including extensions, over 100sqm floor space. Including change of use or conversion to non-residential and between non-residential use classes.* | *• BREEAM 'Excellent'<br>• 35% reduction in CO2 emissions over Building Regulations (2013)<br>• Submit energy statement<br>• Submit Sustainable Construction Checklist<br>• BREEAM refurbishment and fit out if one or more of the Parts are applicable as laid out in the Scope of the technical manual* |
| *Major new non-residential buildings, including extensions, over 1,000sqm floor space* | *• Zero carbon standards from 2019<br>• BREEAM 'Excellent'<br>• Submit energy statement<br>• Submit Sustainable Construction Checklist* |

# 4. Energy Efficiency Assessment

## 4.1. Non-domestic Assessment Methodology

4.1.1. Environmental Economics have modelled the proposed units using Design Builder V6.1.8.021. The software provides a number of outputs which can be used to assess and compare the improvements from any number of build specifications in terms of:

1. *Building regulations compliance*
2. *Energy usage per year (kWh/annum)*
3. *Carbon emissions as a measure of building regulations compliance ($kgCO_2 m^2$/year)*
4. *More detailed breakdowns by type of end use*
5. *Overheating risk*

4.1.2. Each of these outputs can be used in different ways to analyse the performance of a non-domestic unit. The requirement for this project, as set out in the previous section, relates to a reduction in $CO_2$ emissions. The analysis, therefore, evaluated the $CO_2$ emissions rate per year for each of the properties on site. The total $CO_2$ emissions rate for each unit is based upon the regulated energy use for:

1. *Heating*
2. *Cooling*
3. *Auxiliary*
4. *Lighting*
5. *Hot Water*

4.1.3. The energy calculation for the space heating and cooling, water heating, as well as the auxiliary electricity and lighting electricity were all assessed using the National Calculation Methodology modelling guide (for buildings other than dwellings in England) 2013.

4.1.4. For reporting purposes the unregulated emissions are also required, therefore the additional energy demand for equipment has been used from the BRUKL calculation output document.

4.1.5. The BRUKL calculation output documents can be found in Appendix A, for each step of the energy hierarchy

4.1.6. The drawings the assessment has been based on can be found in Appendix B.

# 5. Design Philosophy

## 5.1. Be Lean

5.1.1. In order to reduce the residual carbon emissions a number of improvements were made to the standard material and product specification.

5.1.2. The fabric of the buildings was improved from basic compliance with Part L 2013 to an enhanced specification. These fabric improvements reduce the energy demand resulting from normal occupation of a property. Improvements to the U-Value of external elements are shown below.

**Table 3 – Non-domestic Fabric Specification**

| *Element* | *Minimum Standard* | *Enhanced Specification* |
|---|---|---|
| - | *$W/m^2k$* | *$W/m^2k$* |
| **External Walls** | 0.35 | 0.182 |
| **Roof** | 0.25 | 0.15 |
| **Ground Floors** | 0.25 | 0.193 |
| **Glazing** | 2.20 | 1.1<br>Frame Factor: 10%<br>T Solar: 0.45<br>L Solar: 0.73 |
| **Air Permeability** | 10 $m^3/hm^2$ | 5.00 $m^3/hm^2$ |

5.1.3. Due to the unique structure of the units, being pre-fabricated storage containers. Enhanced thermal specification data has been taken from a study providing examples on appropriate construction build-ups. See Appendix C.

5.1.4. As the units are sufficiently glazed, the strategy proposes high performing double glazing. An example datasheet is provided in Appendix D demonstrating thermal performance.

5.1.5. The development has proposed the use of a Green roof on Pavilion 01 and a BioSolar on Pavilion 02. An example datasheet is provided in Appendix E demonstrating thermal performance.

5.1.6. Highly efficient lighting – LED – has been specified to all zones.

5.1.7. To comply with the Be Lean specification, the HVAC system was modelled with a gas boiler for the heating. No cooling has been proposed for the development.

5.1.8. Criterion 3 of Part L2a (Limiting the effects of heat gains in the summer) has been addressed through the use of external shading to the south of Pavilion 01, and double glazing to minimise solar gains.

## 5.2. Be Clean

5.2.1. The GLA "Energy Planning" document provides guidance relating to the required hierarchical approach that should be followed when selecting energy systems.

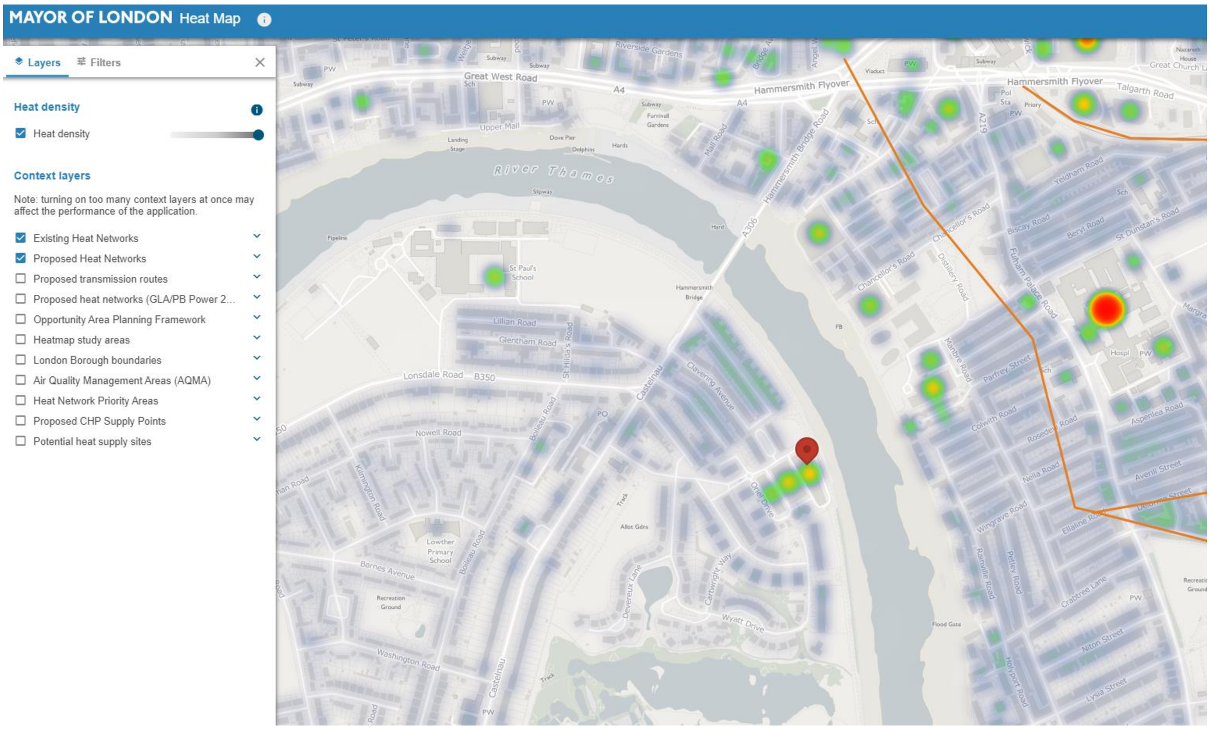
5.2.2. As required by the LP2016 the authors have made reference to the London Heat Map to ascertain the potential connection to existing or planned district heating schemes.

5.2.3. Utilising the interactive search opportunities, all the potential sources of heat have been selected:

1. *Major energy loads*
2. *Major energy supply plants*
3. *Networks*
4. *Opportunities*

5.2.4. The resulting heat map is reproduced in full in Figure 3. The development is not within the vicinity of the existing heat network, and it is not near a planned future expansion of the existing network.

**Figure 3 – London Heat Map extract**



5.2.5. LP2016 also requires the consideration of site wide heat networks, including Combined Heat and Power (CHP).

5.2.6. CHP networks can be appropriate and desirable in situations where there is a large background demand for heat energy across a wide time period. In such cases the central plan benefits from a steady requirement for heat energy and as such can be sized with modular CHP/boiler plant.

5.2.7. An example of such a development would be a mixed use development which includes leisure/commercial/hotels and domestic housing. In this example there would be a "base load" for heat energy which could justify the investment in an energy centre.

5.2.8. Due to the low heat demand of the development CHP has not been considered a viable option in this instance.

## 5.3. Be Green

5.3.1. This report does not seek to compare the various types of renewable energy systems.

5.3.2. The client is fully committed to adopting suitable renewable energy technologies where technically feasible. It is proposed that Air Source Heat Pumps are used to supply heating with an Electric Instantaneous Hot Water for the domestic hot water. See Appendix F for product information and efficiency data for an example ASHP that could be used to fuel the development.

5.3.3. The inclusion of 3.0Wp of PV is proposed to Pavilion 02. See Appendix G for PV Layout.

## 5.4. Monitoring

5.4.1. It is anticipated that the renewable technologies will be installed by professionally certified installation contractors and therefore will benefit from meters which log the energy consumption and generation.

# 6. Results

6.1.1. The annual emissions rate for the baseline TER is 6.3 Tonnes of CO2 per annum. Therefore a reduction of at least 2.205 Tonnes of CO2 per annum is required. The annual emissions rate after application of the energy hierarchy is 3.2 Tonnes of CO2 per annum.

6.1.2. In accordance with Sustainable Construction Checklist, the reduction in CO2 emissions for each stage of the energy hierarchy, using SAP10 figures, is as follows:

- Be Lean: 19%
- Be Clean: 0%
- Be Green: 30%

6.1.3. The total regulated carbon dioxide savings after applying the energy hierarchy is 49% when SAP10 is utilised.

# Appendix A

**Be Lean BRUKL**

# BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

**Project name**

## Pavillion 1

As designed

**Date:** Fri Jan 22 09:53:15 2021

## Administrative information

### Building Details

**Address:** Harrods Wharf, London,

### Certification tool

**Calculation engine:** SBEM

**Calculation engine version:** v5.6.b.0

**Interface to calculation engine:** DesignBuilder SBEM

**Interface to calculation engine version:** v6.1.8

**BRUKL compliance check version:** v5.6.b.0

### Certifier details

**Name:** Miss Sophie Beesley

**Telephone number:** 01582 544250

**Address:** 8 Cardiff Road, Luton, LU1 1PP

## Criterion 1: The calculated $CO_2$ emission rate for the building must not exceed the target

| | |
|---|---|
| $CO_2$ emission rate from the notional building, $kgCO_2/m^2$.annum | 56.8 |
| Target $CO_2$ emission rate (TER), $kgCO_2/m^2$.annum | 56.8 |
| Building $CO_2$ emission rate (BER), $kgCO_2/m^2$.annum | 43.7 |
| Are emissions from the building less than or equal to the target? | BER =< TER |
| Are as built details the same as used in the BER calculations? | Separate submission |

## Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

**Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.**

**Building fabric**

| Element | $U_{a-Limit}$ | $U_{a-Calc}$ | $U_{i-Calc}$ | Surface where the maximum value occurs* |
|---|---|---|---|---|
| Wall** | 0.35 | 0.18 | 0.18 | "Pavillion 1 - Cafe_W_5" |
| Floor | 0.25 | 0.19 | 0.19 | "Pavillion 1 - Cafe_S_3" |
| Roof | 0.25 | 0.15 | 0.15 | "Pavillion 1 - Cafe_R_4" |
| Windows***, roof windows, and rooflights | 2.2 | 1.1 | 1.1 | "Pavillion 1 - Cafe_G_6" |
| Personnel doors | 2.2 | 0.81 | 0.81 | "Pavillion 1 - WCs_D_9" |
| Vehicle access & similar large doors | 1.5 | - | - | "No external vehicle access doors" |
| High usage entrance doors | 3.5 | - | - | "No external high usage entrance doors" |

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a-Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i-Calc}$ = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

| Air Permeability | Worst acceptable standard | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 10 | 5 |

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**Building services**

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

| | |
|---|---|
| **Whole building lighting automatic monitoring & targeting with alarms for out-of-range values** | YES |
| **Whole building electric power factor achieved by power factor correction** | >0.95 |

1- Central Rads with Gas Boiler

| | Heating efficiency | Cooling efficiency | Radiant efficiency | SFP [W/(l/s)] | HR efficiency |
|---|---|---|---|---|---|
| **This system** | 0.91 | - | - | - | - |
| **Standard value** | 0.91* | N/A | N/A | N/A | N/A |
| **Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system** | | | | | YES |

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

1- Point of Use - Gas

| | Water heating efficiency | Storage loss factor [kWh/litre per day] |
|---|---|---|
| **This building** | 0.91 | - |
| **Standard value** | 0.9* | N/A |

* Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73.

**Local mechanical ventilation, exhaust, and terminal units**

| ID | System type in Non-domestic Building Services Compliance Guide |
|---|---|
| A | Local supply or extract ventilation units serving a single area |
| B | Zonal supply system where the fan is remote from the zone |
| C | Zonal extract system where the fan is remote from the zone |
| D | Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery |
| E | Local supply and extract ventilation system serving a single area with heating and heat recovery |
| F | Other local ventilation units |
| G | Fan-assisted terminal VAV unit |
| H | Fan coil units |
| I | Zonal extract system where the fan is remote from the zone with grease filter |

| Zone name | SFP [W/(l/s)] | | | | | | | | | HR efficiency | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID of system type** | A | B | C | D | E | F | G | H | I | | |
| **Standard value** | 0.3 | 1.1 | 0.5 | 1.9 | 1.6 | 0.5 | 1.1 | 0.5 | 1 | Zone | Standard |
| Pavillion 1 - Cafe | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |
| Pavillion 1 - Cafe BOH | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |
| Pavillion 1 - WCs | 0.3 | - | - | - | - | - | - | - | - | - | N/A |

| **General lighting and display lighting** | Luminous efficacy [lm/W] | | | |
|---|---|---|---|---|
| **Zone name** | **Luminaire** | **Lamp** | **Display lamp** | **General lighting [W]** |
| **Standard value** | 60 | 60 | 22 | |
| Pavillion 1 - Cafe | - | 100 | 100 | 133 |
| Pavillion 1 - Cafe BOH | - | 100 | - | 174 |
| Pavillion 1 - WCs | - | 100 | - | 95 |

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## Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

| Zone | Solar gain limit exceeded? (%) | Internal blinds used? |
|---|---|---|
| Pavillion 1 - Cafe | NO (-1.9%) | NO |

## Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

## Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

## EPBD (Recast): Consideration of alternative energy systems

| | |
|---|---|
| **Were alternative energy systems considered and analysed as part of the design process?** | NO |
| Is evidence of such assessment available as a separate submission? | NO |
| Are any such measures included in the proposed design? | NO |

# Technical Data Sheet (Actual vs. Notional Building)

## Building Global Parameters

| | Actual | Notional |
|---|---|---|
| Area [m²] | 109.5 | 109.5 |
| External area [m²] | 359.2 | 359.2 |
| Weather | LON | LON |
| Infiltration [m³/hm²@ 50Pa] | 5 | 5 |
| Average conductance [W/K] | 108.27 | 156.66 |
| Average U-value [W/m²K] | 0.3 | 0.44 |
| Alpha value* [%] | 33.81 | 23.75 |

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

## Building Use

| % Area | Building Type |
|---|---|
| | A1/A2 Retail/Financial and Professional services |
| 100 | **A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways** |
| | B1 Offices and Workshop businesses |
| | B2 to B7 General Industrial and Special Industrial Groups |
| | B8 Storage or Distribution |
| | C1 Hotels |
| | C2 Residential Institutions: Hospitals and Care Homes |
| | C2 Residential Institutions: Residential schools |
| | C2 Residential Institutions: Universities and colleges |
| | C2A Secure Residential Institutions |
| | Residential spaces |
| | D1 Non-residential Institutions: Community/Day Centre |
| | D1 Non-residential Institutions: Libraries, Museums, and Galleries |
| | D1 Non-residential Institutions: Education |
| | D1 Non-residential Institutions: Primary Health Care Building |
| | D1 Non-residential Institutions: Crown and County Courts |
| | D2 General Assembly and Leisure, Night Clubs, and Theatres |
| | Others: Passenger terminals |
| | Others: Emergency services |
| | Others: Miscellaneous 24hr activities |
| | Others: Car Parks 24 hrs |
| | Others: Stand alone utility block |

## Energy Consumption by End Use [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Heating | 34.04 | 54.76 |
| Cooling | 0 | 0 |
| Auxiliary | 17.69 | 12.43 |
| Lighting | 23.42 | 44.2 |
| Hot water | 71.76 | 75.53 |
| Equipment* | 120.61 | 120.61 |
| **TOTAL**** | **146.92** | **186.92** |

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

## Energy Production by Technology [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Photovoltaic systems | 0 | 0 |
| Wind turbines | 0 | 0 |
| CHP generators | 0 | 0 |
| Solar thermal systems | 0 | 0 |

## Energy & $CO_2$ Emissions Summary

| | Actual | Notional |
|---|---|---|
| Heating + cooling demand [MJ/m²] | 461.49 | 582.27 |
| Primary energy* [kWh/m²] | 252.15 | 328.46 |
| Total emissions [kg/m²] | 43.7 | 56.8 |

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

## HVAC Systems Performance

| System Type | Heat dem MJ/m2 | Cool dem MJ/m2 | Heat con kWh/m2 | Cool con kWh/m2 | Aux con kWh/m2 | Heat SSEEF | Cool SSEER | Heat gen SEFF | Cool gen SEER |
|---|---|---|---|---|---|---|---|---|---|
| [ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas | | | | | | | | | |
| Actual | 104.8 | 356.7 | 34 | 0 | 17.7 | 0.86 | 0 | 0.91 | 0 |
| Notional | 161.5 | 420.8 | 54.8 | 0 | 12.4 | 0.82 | 0 | ---- | ---- |

### Key to terms

| | |
|---|---|
| Heat dem [MJ/m2] | = Heating energy demand |
| Cool dem [MJ/m2] | = Cooling energy demand |
| Heat con [kWh/m2] | = Heating energy consumption |
| Cool con [kWh/m2] | = Cooling energy consumption |
| Aux con [kWh/m2] | = Auxiliary energy consumption |
| Heat SSEFF | = Heating system seasonal efficiency (for notional building, value depends on activity glazing class) |
| Cool SSEER | = Cooling system seasonal energy efficiency ratio |
| Heat gen SSEFF | = Heating generator seasonal efficiency |
| Cool gen SSEER | = Cooling generator seasonal energy efficiency ratio |
| ST | = System type |
| HS | = Heat source |
| HFT | = Heating fuel type |
| CFT | = Cooling fuel type |

# Key Features

**The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.**

**Building fabric**

| Element | $U_{i-Typ}$ | $U_{i-Min}$ | Surface where the minimum value occurs* |
|---|---|---|---|
| Wall | 0.23 | 0.18 | "Pavillion 1 - Cafe_W_5" |
| Floor | 0.2 | 0.19 | "Pavillion 1 - Cafe_S_3" |
| Roof | 0.15 | 0.15 | "Pavillion 1 - Cafe_R_4" |
| Windows, roof windows, and rooflights | 1.5 | 1.1 | "Pavillion 1 - Cafe_G_6" |
| Personnel doors | 1.5 | 0.81 | "Pavillion 1 - WCs_D_9" |
| Vehicle access & similar large doors | 1.5 | - | "No external vehicle access doors" |
| High usage entrance doors | 1.5 | - | "No external high usage entrance doors" |

$U_{i-Typ}$ = Typical individual element U-values [W/(m²K)]  $U_{i-Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

| Air Permeability | Typical value | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 5 | 5 |

# BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

**Project name**

## Pavillion 2

As designed

**Date:** Fri Jan 22 09:56:01 2021

## Administrative information

### Building Details

**Address:** Harrods Wharf, London,

### Certification tool

**Calculation engine:** SBEM

**Calculation engine version:** v5.6.b.0

**Interface to calculation engine:** DesignBuilder SBEM

**Interface to calculation engine version:** v6.1.8

**BRUKL compliance check version:** v5.6.b.0

### Certifier details

**Name:** Miss Sophie Beesley

**Telephone number:** 01582 544250

**Address:** 8 Cardiff Road, Luton, LU1 1PP

## Criterion 1: The calculated $CO_2$ emission rate for the building must not exceed the target

| | |
|---|---|
| $CO_2$ emission rate from the notional building, $kgCO_2/m^2$.annum | 25.9 |
| Target $CO_2$ emission rate (TER), $kgCO_2/m^2$.annum | 25.9 |
| Building $CO_2$ emission rate (BER), $kgCO_2/m^2$.annum | 22.5 |
| Are emissions from the building less than or equal to the target? | BER =< TER |
| Are as built details the same as used in the BER calculations? | Separate submission |

## Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

**Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.**

**Building fabric**

| Element | $U_{a\text{-}Limit}$ | $U_{a\text{-}Calc}$ | $U_{i\text{-}Calc}$ | Surface where the maximum value occurs* |
|---|---|---|---|---|
| Wall** | 0.35 | 0.18 | 0.18 | "Pavillion 2 - ACC WC_W_7" |
| Floor | 0.25 | 0.19 | 0.19 | "Pavillion 2 - ACC WC_S_3" |
| Roof | 0.25 | 0.15 | 0.15 | "Pavillion 2 - ACC WC_R_4" |
| Windows***, roof windows, and rooflights | 2.2 | 1.1 | 1.1 | "Pavillion 2 - Entrance Lobby_G_6" |
| Personnel doors | 2.2 | 0.81 | 0.81 | "Pavillion 2 - Storage_D_6" |
| Vehicle access & similar large doors | 1.5 | - | - | "No external vehicle access doors" |
| High usage entrance doors | 3.5 | - | - | "No external high usage entrance doors" |

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

| Air Permeability | Worst acceptable standard | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 10 | 5 |

**Building services**

**The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.**

| | |
|---|---|
| **Whole building lighting automatic monitoring & targeting with alarms for out-of-range values** | YES |
| **Whole building electric power factor achieved by power factor correction** | >0.95 |

1- Central Rads with Gas Boiler

| | Heating efficiency | Cooling efficiency | Radiant efficiency | SFP [W/(l/s)] | HR efficiency |
|---|---|---|---|---|---|
| **This system** | 0.91 | - | - | - | - |
| **Standard value** | 0.91* | N/A | N/A | N/A | N/A |
| **Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system** | YES | | | | |
| * Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82. | | | | | |

1- Point of Use - Gas

| | Water heating efficiency | Storage loss factor [kWh/litre per day] |
|---|---|---|
| **This building** | 0.91 | - |
| **Standard value** | 0.9* | N/A |
| * Standard shown is for gas boilers >30 kW output. For boilers <=30 kW output, limiting efficiency is 0.73. | | |

**Local mechanical ventilation, exhaust, and terminal units**

| ID | System type in Non-domestic Building Services Compliance Guide |
|---|---|
| A | Local supply or extract ventilation units serving a single area |
| B | Zonal supply system where the fan is remote from the zone |
| C | Zonal extract system where the fan is remote from the zone |
| D | Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery |
| E | Local supply and extract ventilation system serving a single area with heating and heat recovery |
| F | Other local ventilation units |
| G | Fan-assisted terminal VAV unit |
| H | Fan coil units |
| I | Zonal extract system where the fan is remote from the zone with grease filter |

| Zone name | SFP [W/(l/s)] | | | | | | | | | HR efficiency | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID of system type** | A | B | C | D | E | F | G | H | I | | |
| **Standard value** | 0.3 | 1.1 | 0.5 | 1.9 | 1.6 | 0.5 | 1.1 | 0.5 | 1 | Zone | Standard |
| Pavillion 2 - ACC WC | 0.3 | - | - | - | - | - | - | - | - | - | N/A |
| Pavillion 2 - ACC WC 1 | 0.3 | - | - | - | - | - | - | - | - | - | N/A |
| Pavillion 2 - Ticket Office | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |
| Pavillion 2 - Staff Lounge | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |

**General lighting and display lighting**

| Zone name | Luminous efficacy [lm/W] Luminaire | Lamp | Display lamp | General lighting [W] |
|---|---|---|---|---|
| **Standard value** | 60 | 60 | 22 | |
| Pavillion 2 - ACC WC | - | 100 | - | 21 |
| Pavillion 2 - Storage 1 | 100 | - | - | 5 |
| Pavillion 2 - ACC WC 1 | - | 100 | - | 20 |
| Pavillion 2 - Entrance Lobby | - | 100 | - | 10 |
| Pavillion 2 - Ticket Office | - | 100 | 100 | 156 |
| Pavillion 2 - Staff Lounge | 100 | - | - | 225 |

| General lighting and display lighting | Luminous efficacy [lm/W] | | | |
|---|---|---|---|---|
| Zone name | Luminaire | Lamp | Display lamp | General lighting [W] |
| **Standard value** | 60 | 60 | 22 | |
| Pavillion 2 - Storage | 100 | - | - | 28 |

## Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

| Zone | Solar gain limit exceeded? (%) | Internal blinds used? |
|---|---|---|
| Pavillion 2 - Ticket Office | NO (-78.6%) | NO |
| Pavillion 2 - Staff Lounge | NO (-10.6%) | NO |

## Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

## Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

## EPBD (Recast): Consideration of alternative energy systems

| | |
|---|---|
| **Were alternative energy systems considered and analysed as part of the design process?** | NO |
| Is evidence of such assessment available as a separate submission? | NO |
| Are any such measures included in the proposed design? | NO |

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# Technical Data Sheet (Actual vs. Notional Building)

## Building Global Parameters

| | Actual | Notional |
|---|---|---|
| Area [m²] | 100.4 | 100.4 |
| External area [m²] | 331.2 | 331.2 |
| Weather | LON | LON |
| Infiltration [m³/hm²@ 50Pa] | 5 | 5 |
| Average conductance [W/K] | 90.75 | 131.98 |
| Average U-value [W/m²K] | 0.27 | 0.4 |
| Alpha value* [%] | 39.39 | 21.69 |

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

## Building Use

| % Area | Building Type |
|---|---|
| 100 | **A1/A2 Retail/Financial and Professional services** |
| | A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways |
| | B1 Offices and Workshop businesses |
| | B2 to B7 General Industrial and Special Industrial Groups |
| | B8 Storage or Distribution |
| | C1 Hotels |
| | C2 Residential Institutions: Hospitals and Care Homes |
| | C2 Residential Institutions: Residential schools |
| | C2 Residential Institutions: Universities and colleges |
| | C2A Secure Residential Institutions |
| | Residential spaces |
| | D1 Non-residential Institutions: Community/Day Centre |
| | D1 Non-residential Institutions: Libraries, Museums, and Galleries |
| | D1 Non-residential Institutions: Education |
| | D1 Non-residential Institutions: Primary Health Care Building |
| | D1 Non-residential Institutions: Crown and County Courts |
| | D2 General Assembly and Leisure, Night Clubs, and Theatres |
| | Others: Passenger terminals |
| | Others: Emergency services |
| | Others: Miscellaneous 24hr activities |
| | Others: Car Parks 24 hrs |
| | Others: Stand alone utility block |

## Energy Consumption by End Use [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Heating | 52.14 | 62.63 |
| Cooling | 0 | 0 |
| Auxiliary | 5.11 | 3.76 |
| Lighting | 16.11 | 19.81 |
| Hot water | 2.11 | 2.22 |
| Equipment* | 21.47 | 21.47 |
| **TOTAL**** | **75.47** | **88.42** |

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

## Energy Production by Technology [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Photovoltaic systems | 0 | 0 |
| Wind turbines | 0 | 0 |
| CHP generators | 0 | 0 |
| Solar thermal systems | 0 | 0 |

## Energy & $CO_2$ Emissions Summary

| | Actual | Notional |
|---|---|---|
| Heating + cooling demand [MJ/m²] | 308.92 | 326.39 |
| Primary energy* [kWh/m²] | 129.7 | 149.67 |
| Total emissions [kg/m²] | 22.5 | 25.9 |

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

## HVAC Systems Performance

| System Type | | Heat dem MJ/m2 | Cool dem MJ/m2 | Heat con kWh/m2 | Cool con kWh/m2 | Aux con kWh/m2 | Heat SSEEF | Cool SSEER | Heat gen SEFF | Cool gen SEER |
|---|---|---|---|---|---|---|---|---|---|---|
| [ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas | | | | | | | | | | |
| | Actual | 160.5 | 148.4 | 52.1 | 0 | 5.1 | 0.86 | 0 | 0.91 | 0 |
| | Notional | 184.7 | 141.7 | 62.6 | 0 | 3.8 | 0.82 | 0 | ---- | ---- |

### Key to terms

| | |
|---|---|
| Heat dem [MJ/m2] | = Heating energy demand |
| Cool dem [MJ/m2] | = Cooling energy demand |
| Heat con [kWh/m2] | = Heating energy consumption |
| Cool con [kWh/m2] | = Cooling energy consumption |
| Aux con [kWh/m2] | = Auxiliary energy consumption |
| Heat SSEFF | = Heating system seasonal efficiency (for notional building, value depends on activity glazing class) |
| Cool SSEER | = Cooling system seasonal energy efficiency ratio |
| Heat gen SSEFF | = Heating generator seasonal efficiency |
| Cool gen SSEER | = Cooling generator seasonal energy efficiency ratio |
| ST | = System type |
| HS | = Heat source |
| HFT | = Heating fuel type |
| CFT | = Cooling fuel type |

# Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

**Building fabric**

| Element | $U_{i\text{-}Typ}$ | $U_{i\text{-}Min}$ | Surface where the minimum value occurs* |
|---|---|---|---|
| Wall | 0.23 | 0.18 | "Pavillion 2 - ACC WC_W_7" |
| Floor | 0.2 | 0.19 | "Pavillion 2 - ACC WC_S_3" |
| Roof | 0.15 | 0.15 | "Pavillion 2 - ACC WC_R_4" |
| Windows, roof windows, and rooflights | 1.5 | 1.1 | "Pavillion 2 - Entrance Lobby_G_6" |
| Personnel doors | 1.5 | 0.81 | "Pavillion 2 - Storage_D_6" |
| Vehicle access & similar large doors | 1.5 | - | "No external vehicle access doors" |
| High usage entrance doors | 1.5 | - | "No external high usage entrance doors" |

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)]

$U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

| Air Permeability | Typical value | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 5 | 5 |

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**Be Green BRUKL**

# BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

**Project name**

## Pavillion 1

As designed

**Date:** Fri Jan 22 10:04:16 2021

## Administrative information

### Building Details

**Address:** Harrods Wharf, London,

### Certification tool

**Calculation engine:** SBEM

**Calculation engine version:** v5.6.b.0

**Interface to calculation engine:** DesignBuilder SBEM

**Interface to calculation engine version:** v6.1.8

**BRUKL compliance check version:** v5.6.b.0

### Certifier details

**Name:** Miss Sophie Beesley

**Telephone number:** 01582 544250

**Address:** 8 Cardiff Road, Luton, LU1 1PP

## Criterion 1: The calculated $CO_2$ emission rate for the building must not exceed the target

| | |
|---|---|
| $CO_2$ emission rate from the notional building, $kgCO_2/m^2$.annum | 62.1 |
| Target $CO_2$ emission rate (TER), $kgCO_2/m^2$.annum | 62.1 |
| Building $CO_2$ emission rate (BER), $kgCO_2/m^2$.annum | 58 |
| Are emissions from the building less than or equal to the target? | BER =< TER |
| Are as built details the same as used in the BER calculations? | Separate submission |

## Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

**Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.**

**Building fabric**

| Element | $U_{a\text{-}Limit}$ | $U_{a\text{-}Calc}$ | $U_{i\text{-}Calc}$ | Surface where the maximum value occurs* |
|---|---|---|---|---|
| Wall** | 0.35 | 0.18 | 0.18 | "Pavillion 1 - Cafe_W_5" |
| Floor | 0.25 | 0.19 | 0.19 | "Pavillion 1 - Cafe_S_3" |
| Roof | 0.25 | 0.15 | 0.15 | "Pavillion 1 - Cafe_R_4" |
| Windows***, roof windows, and rooflights | 2.2 | 1.1 | 1.1 | "Pavillion 1 - Cafe_G_6" |
| Personnel doors | 2.2 | 0.81 | 0.81 | "Pavillion 1 - WCs_D_9" |
| Vehicle access & similar large doors | 1.5 | - | - | "No external vehicle access doors" |
| High usage entrance doors | 3.5 | - | - | "No external high usage entrance doors" |

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

| Air Permeability | Worst acceptable standard | This building |
|---|---|---|
| $m^3/(h.m^2)$ at 50 Pa | 10 | 5 |

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**Building services**

**The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.**

| | |
|---|---|
| **Whole building lighting automatic monitoring & targeting with alarms for out-of-range values** | YES |
| **Whole building electric power factor achieved by power factor correction** | >0.95 |

1- Central Rads with Electric

| | Heating efficiency | Cooling efficiency | Radiant efficiency | SFP [W/(l/s)] | HR efficiency |
|---|---|---|---|---|---|
| **This system** | 3.77 | - | - | - | - |
| **Standard value** | 2.5* | N/A | N/A | N/A | N/A |
| **Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system** | | | | | YES |

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.

1- Point of Use - Electric

| | Water heating efficiency | Storage loss factor [kWh/litre per day] |
|---|---|---|
| **This building** | 1 | - |
| **Standard value** | 1 | N/A |

**Local mechanical ventilation, exhaust, and terminal units**

| ID | System type in Non-domestic Building Services Compliance Guide |
|---|---|
| A | Local supply or extract ventilation units serving a single area |
| B | Zonal supply system where the fan is remote from the zone |
| C | Zonal extract system where the fan is remote from the zone |
| D | Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery |
| E | Local supply and extract ventilation system serving a single area with heating and heat recovery |
| F | Other local ventilation units |
| G | Fan-assisted terminal VAV unit |
| H | Fan coil units |
| I | Zonal extract system where the fan is remote from the zone with grease filter |

| Zone name | SFP [W/(l/s)] | | | | | | | | | HR efficiency | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID of system type | A | B | C | D | E | F | G | H | I | | |
| Standard value | 0.3 | 1.1 | 0.5 | 1.9 | 1.6 | 0.5 | 1.1 | 0.5 | 1 | Zone | Standard |
| Pavillion 1 - Cafe | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |
| Pavillion 1 - Cafe BOH | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |
| Pavillion 1 - WCs | 0.3 | - | - | - | - | - | - | - | - | - | N/A |

**General lighting and display lighting**

| Zone name | Luminous efficacy [lm/W] Luminaire | Lamp | Display lamp | General lighting [W] |
|---|---|---|---|---|
| Standard value | 60 | 60 | 22 | |
| Pavillion 1 - Cafe | - | 100 | 100 | 133 |
| Pavillion 1 - Cafe BOH | - | 100 | - | 174 |
| Pavillion 1 - WCs | - | 100 | - | 95 |

## Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

| Zone | Solar gain limit exceeded? (%) | Internal blinds used? |
|---|---|---|
| Pavillion 1 - Cafe | NO (-1.9%) | NO |

## Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

## Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

## EPBD (Recast): Consideration of alternative energy systems

| | |
|---|---|
| **Were alternative energy systems considered and analysed as part of the design process?** | NO |
| Is evidence of such assessment available as a separate submission? | NO |
| Are any such measures included in the proposed design? | NO |

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# Technical Data Sheet (Actual vs. Notional Building)

## Building Global Parameters

| | Actual | Notional |
|---|---|---|
| Area [m²] | 109.5 | 109.5 |
| External area [m²] | 359.2 | 359.2 |
| Weather | LON | LON |
| Infiltration [m³/hm²@ 50Pa] | 5 | 5 |
| Average conductance [W/K] | 108.27 | 156.66 |
| Average U-value [W/m²K] | 0.3 | 0.44 |
| Alpha value* [%] | 33.81 | 23.75 |

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

## Building Use

| % Area | Building Type |
|---|---|
| | A1/A2 Retail/Financial and Professional services |
| 100 | **A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways** |
| | B1 Offices and Workshop businesses |
| | B2 to B7 General Industrial and Special Industrial Groups |
| | B8 Storage or Distribution |
| | C1 Hotels |
| | C2 Residential Institutions: Hospitals and Care Homes |
| | C2 Residential Institutions: Residential schools |
| | C2 Residential Institutions: Universities and colleges |
| | C2A Secure Residential Institutions |
| | Residential spaces |
| | D1 Non-residential Institutions: Community/Day Centre |
| | D1 Non-residential Institutions: Libraries, Museums, and Galleries |
| | D1 Non-residential Institutions: Education |
| | D1 Non-residential Institutions: Primary Health Care Building |
| | D1 Non-residential Institutions: Crown and County Courts |
| | D2 General Assembly and Leisure, Night Clubs, and Theatres |
| | Others: Passenger terminals |
| | Others: Emergency services |
| | Others: Miscellaneous 24hr activities |
| | Others: Car Parks 24 hrs |
| | Others: Stand alone utility block |

## Energy Consumption by End Use [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Heating | 8.22 | 18.46 |
| Cooling | 0 | 0 |
| Auxiliary | 17.69 | 12.43 |
| Lighting | 23.42 | 44.2 |
| Hot water | 65.3 | 75.53 |
| Equipment* | 120.61 | 120.61 |
| **TOTAL**** | **114.64** | **150.62** |

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

## Energy Production by Technology [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Photovoltaic systems | 0 | 0 |
| Wind turbines | 0 | 0 |
| CHP generators | 0 | 0 |
| Solar thermal systems | 0 | 0 |

## Energy & $CO_2$ Emissions Summary

| | Actual | Notional |
|---|---|---|
| Heating + cooling demand [MJ/m²] | 461.49 | 582.27 |
| Primary energy* [kWh/m²] | 343.13 | 307.83 |
| Total emissions [kg/m²] | 58 | 62.1 |

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

| HVAC Systems Performance | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| System Type | Heat dem MJ/m2 | Cool dem MJ/m2 | Heat con kWh/m2 | Cool con kWh/m2 | Aux con kWh/m2 | Heat SSEEF | Cool SSEER | Heat gen SEFF | Cool gen SEER |
| [ST] Central heating using water: radiators, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Natural Gas | | | | | | | | | |
| Actual | 104.8 | 356.7 | 8.2 | 0 | 17.7 | 3.54 | 0 | 3.77 | 0 |
| Notional | 161.5 | 420.8 | 18.5 | 0 | 12.4 | 2.43 | 0 | ---- | ---- |

**Key to terms**

| | |
|---|---|
| Heat dem [MJ/m2] | = Heating energy demand |
| Cool dem [MJ/m2] | = Cooling energy demand |
| Heat con [kWh/m2] | = Heating energy consumption |
| Cool con [kWh/m2] | = Cooling energy consumption |
| Aux con [kWh/m2] | = Auxiliary energy consumption |
| Heat SSEFF | = Heating system seasonal efficiency (for notional building, value depends on activity glazing class) |
| Cool SSEER | = Cooling system seasonal energy efficiency ratio |
| Heat gen SSEFF | = Heating generator seasonal efficiency |
| Cool gen SSEER | = Cooling generator seasonal energy efficiency ratio |
| ST | = System type |
| HS | = Heat source |
| HFT | = Heating fuel type |
| CFT | = Cooling fuel type |

# Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

**Building fabric**

| Element | $U_{i-Typ}$ | $U_{i-Min}$ | Surface where the minimum value occurs* |
|---|---|---|---|
| Wall | 0.23 | 0.18 | "Pavillion 1 - Cafe_W_5" |
| Floor | 0.2 | 0.19 | "Pavillion 1 - Cafe_S_3" |
| Roof | 0.15 | 0.15 | "Pavillion 1 - Cafe_R_4" |
| Windows, roof windows, and rooflights | 1.5 | 1.1 | "Pavillion 1 - Cafe_G_6" |
| Personnel doors | 1.5 | 0.81 | "Pavillion 1 - WCs_D_9" |
| Vehicle access & similar large doors | 1.5 | - | "No external vehicle access doors" |
| High usage entrance doors | 1.5 | - | "No external high usage entrance doors" |

$U_{i-Typ}$ = Typical individual element U-values [W/(m²K)]

$U_{i-Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

| Air Permeability | Typical value | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 5 | 5 |

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# BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

**Project name**

## Pavillion 2

As designed

**Date:** Fri Jan 22 10:06:18 2021

## Administrative information

### Building Details

**Address:** Harrods Wharf, London,

### Certification tool

**Calculation engine:** SBEM

**Calculation engine version:** v5.6.b.0

**Interface to calculation engine:** DesignBuilder SBEM

**Interface to calculation engine version:** v6.1.8

**BRUKL compliance check version:** v5.6.b.0

### Certifier details

**Name:** Miss Sophie Beesley

**Telephone number:** 01582 544250

**Address:** 8 Cardiff Road, Luton, LU1 1PP

## Criterion 1: The calculated $CO_2$ emission rate for the building must not exceed the target

| | |
|---|---|
| $CO_2$ emission rate from the notional building, $kgCO_2/m^2$.annum | 23.3 |
| Target $CO_2$ emission rate (TER), $kgCO_2/m^2$.annum | 23.3 |
| Building $CO_2$ emission rate (BER), $kgCO_2/m^2$.annum | 7 |
| Are emissions from the building less than or equal to the target? | BER =< TER |
| Are as built details the same as used in the BER calculations? | Separate submission |

## Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

**Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.**

**Building fabric**

| Element | $U_{a-Limit}$ | $U_{a-Calc}$ | $U_{i-Calc}$ | Surface where the maximum value occurs* |
|---|---|---|---|---|
| Wall** | 0.35 | 0.18 | 0.18 | "Pavillion 2 - ACC WC_W_7" |
| Floor | 0.25 | 0.19 | 0.19 | "Pavillion 2 - ACC WC_S_3" |
| Roof | 0.25 | 0.15 | 0.15 | "Pavillion 2 - ACC WC_R_4" |
| Windows***, roof windows, and rooflights | 2.2 | 1.1 | 1.1 | "Pavillion 2 - Entrance Lobby_G_6" |
| Personnel doors | 2.2 | 0.81 | 0.81 | "Pavillion 2 - Storage_D_6" |
| Vehicle access & similar large doors | 1.5 | - | - | "No external vehicle access doors" |
| High usage entrance doors | 3.5 | - | - | "No external high usage entrance doors" |

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
$U_{a-Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
$U_{i-Calc}$ = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

| Air Permeability | Worst acceptable standard | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 10 | 5 |

Page 1 of 6

**Building services**

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

| | |
|---|---|
| **Whole building lighting automatic monitoring & targeting with alarms for out-of-range values** | YES |
| **Whole building electric power factor achieved by power factor correction** | >0.95 |

1- Central Rads with Electric

| | Heating efficiency | Cooling efficiency | Radiant efficiency | SFP [W/(l/s)] | HR efficiency |
|---|---|---|---|---|---|
| **This system** | 3.77 | - | - | - | - |
| **Standard value** | 2.5* | N/A | N/A | N/A | N/A |
| **Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system** | | | | | YES |

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.

1- Point of Use - Electric

| | Water heating efficiency | Storage loss factor [kWh/litre per day] |
|---|---|---|
| **This building** | 1 | - |
| **Standard value** | 1 | N/A |

**Local mechanical ventilation, exhaust, and terminal units**

| ID | System type in Non-domestic Building Services Compliance Guide |
|---|---|
| A | Local supply or extract ventilation units serving a single area |
| B | Zonal supply system where the fan is remote from the zone |
| C | Zonal extract system where the fan is remote from the zone |
| D | Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery |
| E | Local supply and extract ventilation system serving a single area with heating and heat recovery |
| F | Other local ventilation units |
| G | Fan-assisted terminal VAV unit |
| H | Fan coil units |
| I | Zonal extract system where the fan is remote from the zone with grease filter |

| Zone name | SFP [W/(l/s)] | | | | | | | | | HR efficiency | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID of system type** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | | |
| **Standard value** | 0.3 | 1.1 | 0.5 | 1.9 | 1.6 | 0.5 | 1.1 | 0.5 | 1 | **Zone** | **Standard** |
| Pavillion 2 - ACC WC | 0.3 | - | - | - | - | - | - | - | - | - | N/A |
| Pavillion 2 - ACC WC 1 | 0.3 | - | - | - | - | - | - | - | - | - | N/A |
| Pavillion 2 - Ticket Office | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |
| Pavillion 2 - Staff Lounge | - | - | - | 1 | - | - | - | - | - | 0.9 | 0.5 |

**General lighting and display lighting**

| Zone name | Luminous efficacy [lm/W] Luminaire | Lamp | Display lamp | General lighting [W] |
|---|---|---|---|---|
| **Standard value** | 60 | 60 | 22 | |
| Pavillion 2 - ACC WC | - | 100 | - | 21 |
| Pavillion 2 - Storage 1 | 100 | - | - | 5 |
| Pavillion 2 - ACC WC 1 | - | 100 | - | 20 |
| Pavillion 2 - Entrance Lobby | - | 100 | - | 10 |
| Pavillion 2 - Ticket Office | - | 100 | 100 | 156 |
| Pavillion 2 - Staff Lounge | 100 | - | - | 225 |
| Pavillion 2 - Storage | 100 | - | - | 28 |

## Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

| Zone | Solar gain limit exceeded? (%) | Internal blinds used? |
|---|---|---|
| Pavillion 2 - Ticket Office | NO (-78.6%) | NO |
| Pavillion 2 - Staff Lounge | NO (-10.6%) | NO |

## Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

## Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

## EPBD (Recast): Consideration of alternative energy systems

| | |
|---|---|
| **Were alternative energy systems considered and analysed as part of the design process?** | NO |
| Is evidence of such assessment available as a separate submission? | NO |
| Are any such measures included in the proposed design? | NO |

# Technical Data Sheet (Actual vs. Notional Building)

## Building Global Parameters

| | Actual | Notional |
|---|---|---|
| Area [m²] | 100.4 | 100.4 |
| External area [m²] | 331.2 | 331.2 |
| Weather | LON | LON |
| Infiltration [m³/hm²@ 50Pa] | 5 | 5 |
| Average conductance [W/K] | 90.75 | 131.98 |
| Average U-value [W/m²K] | 0.27 | 0.4 |
| Alpha value* [%] | 39.39 | 21.69 |

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

## Building Use

| % Area | Building Type |
|---|---|
| 100 | **A1/A2 Retail/Financial and Professional services** |
| | A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways |
| | B1 Offices and Workshop businesses |
| | B2 to B7 General Industrial and Special Industrial Groups |
| | B8 Storage or Distribution |
| | C1 Hotels |
| | C2 Residential Institutions: Hospitals and Care Homes |
| | C2 Residential Institutions: Residential schools |
| | C2 Residential Institutions: Universities and colleges |
| | C2A Secure Residential Institutions |
| | Residential spaces |
| | D1 Non-residential Institutions: Community/Day Centre |
| | D1 Non-residential Institutions: Libraries, Museums, and Galleries |
| | D1 Non-residential Institutions: Education |
| | D1 Non-residential Institutions: Primary Health Care Building |
| | D1 Non-residential Institutions: Crown and County Courts |
| | D2 General Assembly and Leisure, Night Clubs, and Theatres |
| | Others: Passenger terminals |
| | Others: Emergency services |
| | Others: Miscellaneous 24hr activities |
| | Others: Car Parks 24 hrs |
| | Others: Stand alone utility block |

## Energy Consumption by End Use [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Heating | 12.59 | 21.11 |
| Cooling | 0 | 0 |
| Auxiliary | 5.11 | 3.76 |
| Lighting | 16.11 | 19.81 |
| Hot water | 1.92 | 2.22 |
| Equipment* | 21.47 | 21.47 |
| **TOTAL**** | **35.73** | **46.9** |

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

## Energy Production by Technology [kWh/m²]

| | Actual | Notional |
|---|---|---|
| Photovoltaic systems | 21.34 | 0 |
| Wind turbines | 0 | 0 |
| CHP generators | 0 | 0 |
| Solar thermal systems | 0 | 0 |

## Energy & $CO_2$ Emissions Summary

| | Actual | Notional |
|---|---|---|
| Heating + cooling demand [MJ/m²] | 308.92 | 326.39 |
| Primary energy* [kWh/m²] | 106.94 | 136.17 |
| Total emissions [kg/m²] | 7 | 23.3 |

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

## HVAC Systems Performance

| System Type | | Heat dem MJ/m2 | Cool dem MJ/m2 | Heat con kWh/m2 | Cool con kWh/m2 | Aux con kWh/m2 | Heat SSEEF | Cool SSEER | Heat gen SEFF | Cool gen SEER |
|---|---|---|---|---|---|---|---|---|---|---|
| [ST] Central heating using water: radiators, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Natural Gas | | | | | | | | | | |
| | Actual | 160.5 | 148.4 | 12.6 | 0 | 5.1 | 3.54 | 0 | 3.77 | 0 |
| | Notional | 184.7 | 141.7 | 21.1 | 0 | 3.8 | 2.43 | 0 | ---- | ---- |

### Key to terms

| | |
|---|---|
| Heat dem [MJ/m2] | = Heating energy demand |
| Cool dem [MJ/m2] | = Cooling energy demand |
| Heat con [kWh/m2] | = Heating energy consumption |
| Cool con [kWh/m2] | = Cooling energy consumption |
| Aux con [kWh/m2] | = Auxiliary energy consumption |
| Heat SSEFF | = Heating system seasonal efficiency (for notional building, value depends on activity glazing class) |
| Cool SSEER | = Cooling system seasonal energy efficiency ratio |
| Heat gen SSEFF | = Heating generator seasonal efficiency |
| Cool gen SSEER | = Cooling generator seasonal energy efficiency ratio |
| ST | = System type |
| HS | = Heat source |
| HFT | = Heating fuel type |
| CFT | = Cooling fuel type |

# Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

**Building fabric**

| Element | $U_{i-Typ}$ | $U_{i-Min}$ | Surface where the minimum value occurs* |
|---|---|---|---|
| Wall | 0.23 | 0.18 | "Pavillion 2 - ACC WC_W_7" |
| Floor | 0.2 | 0.19 | "Pavillion 2 - ACC WC_S_3" |
| Roof | 0.15 | 0.15 | "Pavillion 2 - ACC WC_R_4" |
| Windows, roof windows, and rooflights | 1.5 | 1.1 | "Pavillion 2 - Entrance Lobby_G_6" |
| Personnel doors | 1.5 | 0.81 | "Pavillion 2 - Storage_D_6" |
| Vehicle access & similar large doors | 1.5 | - | "No external vehicle access doors" |
| High usage entrance doors | 1.5 | - | "No external high usage entrance doors" |

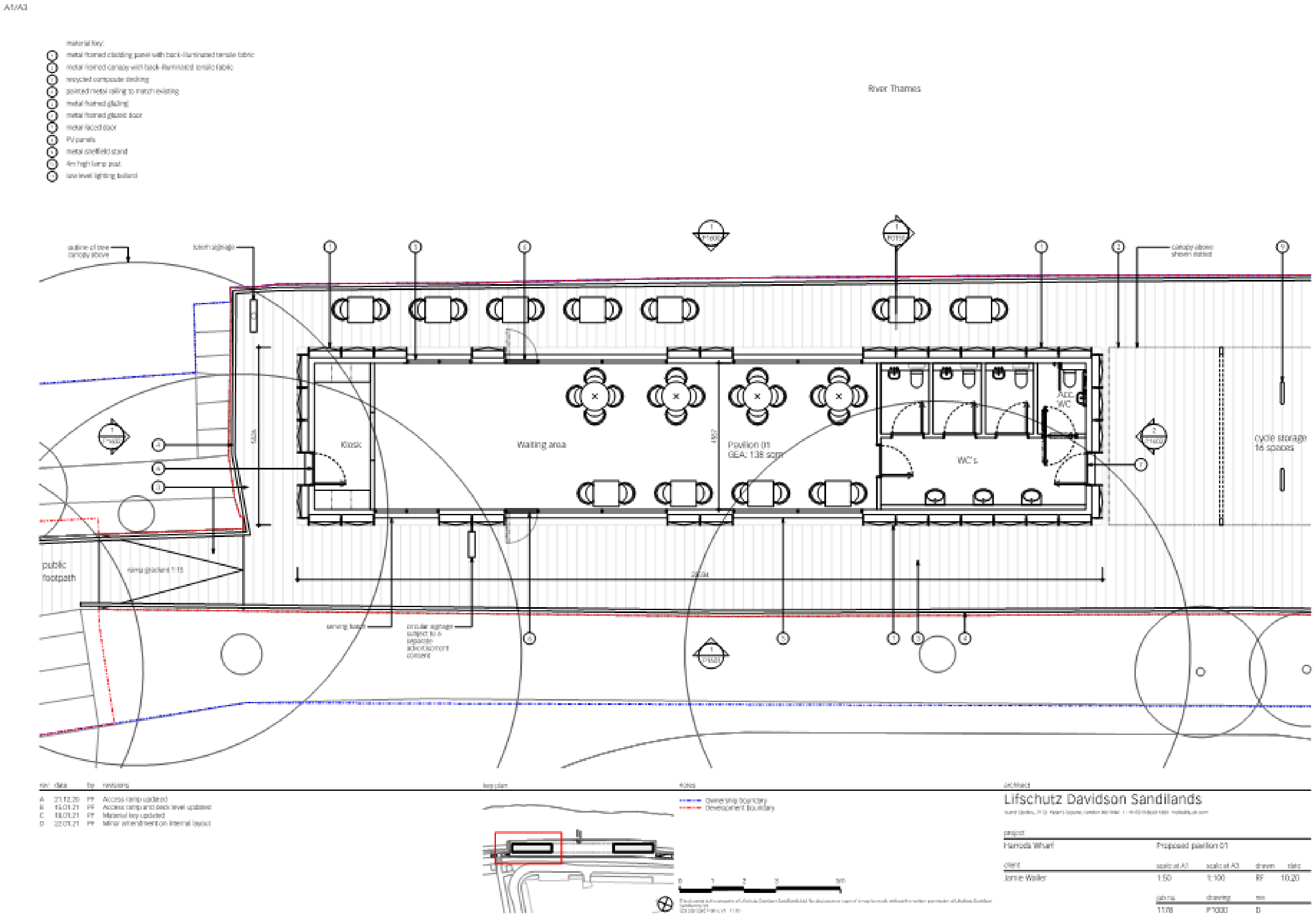
$U_{i-Typ}$ = Typical individual element U-values [W/(m²K)]

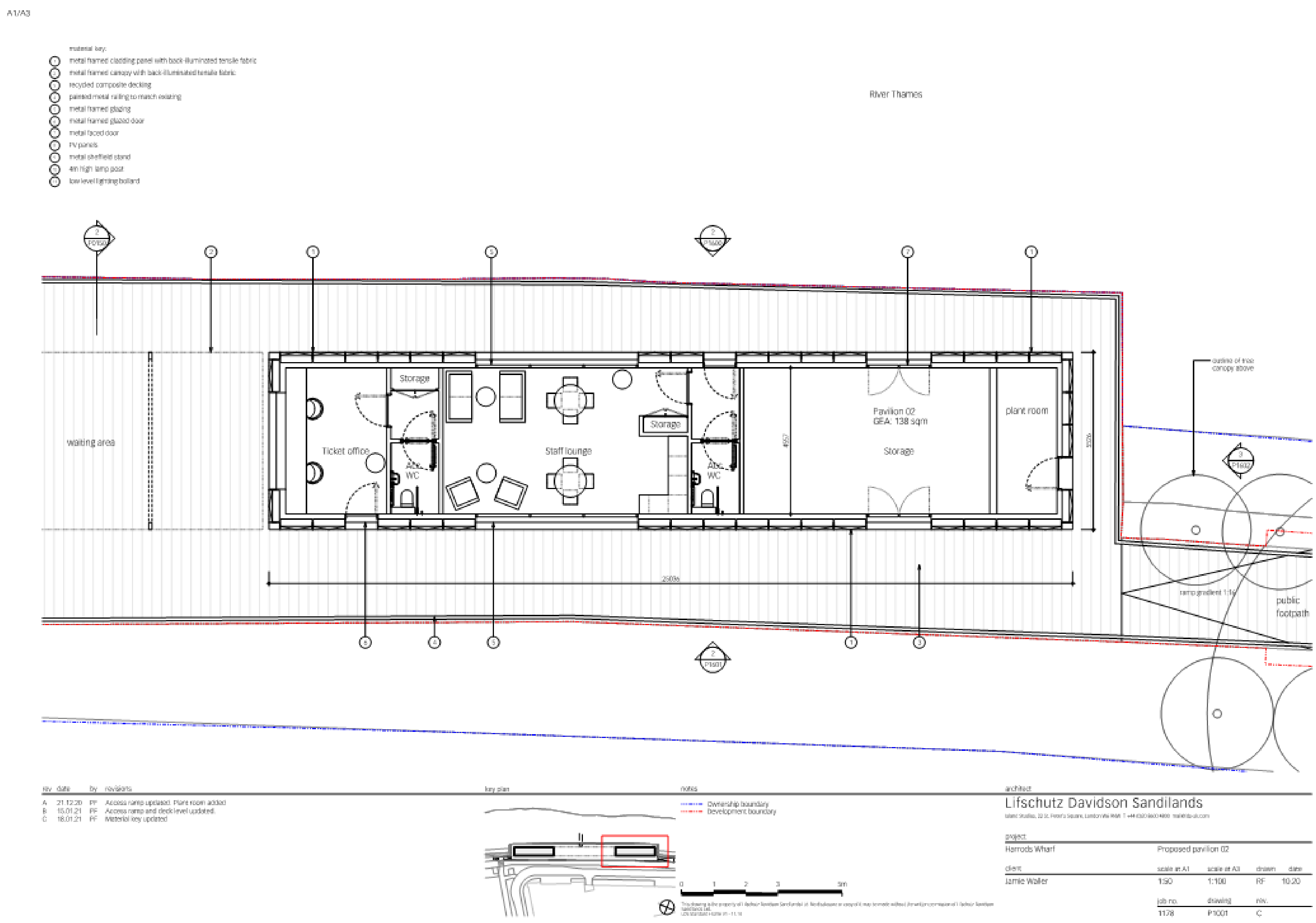
$U_{i-Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

| Air Permeability | Typical value | This building |
|---|---|---|
| m³/(h.m²) at 50 Pa | 5 | 5 |

# Appendix B


A1/A3
material key:
metal framed cladding panel with back-illuminated tensile fabric
metal framed canopy with back-illuminated tensile fabric
recycled composite decking
painted metal railing to match existing
metal framed glazing
metal framed glazed door
metal faced door
PV panels
metal sheffield stand
4m high lamp post
low level lighting bollard
River Thames
Kiosk
Waiting area
Pavilion 01
GEA: 138 sqm
WC's
Acc. WC
cycle storage
16 spaces
public
footpath
ownership boundary
Development boundary
Lifschutz Davidson Sandilands
Harrods Wharf
Proposed pavilion 01
Jamie Waller
1:50
1:100
RF
10.20
1178
P1000
D


A1/A3
material key:
metal framed cladding panel with back-illuminated tensile fabric
metal framed canopy with back-illuminated tensile fabric
recycled composite decking
painted metal railing to match existing
metal framed glazing
metal framed glazed door
metal faced door
PV panels
metal sheffield stand
4m high lamp post
low level lighting bollard
River Thames
waiting area
Storage
Ticket office
Acc. WC
Staff lounge
Storage
Acc. WC
Pavilion 02
GEA: 138 sqm
Storage
plant room
outline of tree canopy above
ramp gradient 1:16
public footpath
rev date by revisions
A 21.12.20 PF Access ramp updated. Plant room added
B 15.01.21 PF Access ramp and deck level updated.
C 18.01.21 PF Material key updated
key plan
notes
Ownership boundary
Development boundary
architect
Lifschutz Davidson Sandilands
project
Harrods Wharf
Proposed pavilion 02
client
Jamie Waller
scale at A1 1:50
scale at A3 1:100
drawn RF
date 10.20
job no. 1178
drawing P1001
rev. C

# Appendix C

sustainability

Article

## Exploring the Potential of Climate-Adaptive Container Building Design under Future Climates Scenarios in Three Different Climate Zones

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**Abstract:** The deployment of containers as building modules has grown in popularity over the past years due to their inherent strength, modular construction, and relatively low cost. The upcycled container architecture is being accepted since it is more eco-friendly than using the traditional building materials with intensive carbon footprint. Moreover, owing to the unquestionable urgency of climate change, existing climate-adaptive design strategies may no longer respond effectively as they are supposed to work in the previous passive design. Therefore, this paper explores the conceptual design for an upcycled shipping container building, which is designed as a carbon-smart modular living solution to a single family house under three design scenarios, related to cold, temperate, and hot–humid climatic zones, respectively. The extra feature of future climate adaption has been added by assessing the projected future climate data with the ASHRAE Standard 55 and Current Handbook of Fundamentals Comfort Model. Compared with the conventional design, Rome would gradually face more failures in conventional climate-adaptive design measures in the coming 60 years, as the growing trends in both cooling and dehumidification demand. Consequently, the appropriate utilization of internal heat gains are proposed to be the most promising measure, followed by the measure of windows sun shading and passive solar direct gain by using low mass, in the upcoming future in Rome. Future climate projection further shows different results in Berlin and Stockholm, where the special attention is around the occasional overheating risk towards the design goal of future thermal comfort.

**Keywords:** upcycling container house; future climate scenario; energy-efficient operated living module; empty containers repositioning

### 1. Introduction

Nowadays, there exist more than 17 million retired shipping containers stacked on the ports worldwide [1]. In the light of substantial trade imbalance between Europe and China, the repositioning of a huge number of stored empty containers could become an evitable problem [2]. In fact, huge expenses are involved in their destruction or transportation to the original country, and their nondegradable construction materials occupy a large landfill space when they are fallen into disuse.

Moreover, most of shipping containers are within the official age or just beyond the "active service" time, making them no longer suitable for transportation purposes [3]. However, this does not mean

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The standardized dimension makes it an ideal building component for modular and prefabricated construction projects [5]. The most popular containers used as building components are 2.438 m in width and 6.096 m or 12.192 m in length. In many national regulations, there is a minimum height limitation of 2.4 m for residential buildings. Thereby, in this context, the residential building design only consider the high cube container with total height of 2.9 m to comply with the minimum clear ceiling height building requirement. Meanwhile, the containers' internal dimensions differ from the external ones. In fact, internal walls have a plurality of corrugations, each one 25 mm depth. This narrows the container inner width by 50 mm due to both a concave and a convex corrugation. The backside, the other side without the door, is corrugated too. The doors have a thickness of 50 mm, which results in a total loss of 75 mm in length. The height of the inner dimension is less compared with the outer dimension. Depending on the floor type, this reduction, consisting of floor clearance and thickness, is approximately 177 mm. Since roof material is also corrugated, the internal height is reduced by slightly more than 200 mm in total [5,26].

**Table 1.** Basic parameters of the most popular containers [1].

| Size | Width (m) | Length (m) | Height (m) | Floor Area ($m^2$) | Volume ($m^3$) | Empty Weight (kg) |
|---|---|---|---|---|---|---|
| 20 ft equivalent unit | 2.438 | 6.096 | 2.591 | 14.86 | 33.1 | 2200 |
| 20 ft high cube equivalent unit | 2.438 | 6.096 | 2.9 | 14.86 | 43.09 | 2350 |
| 40 ft equivalent unit | 2.438 | 12.192 | 2.591 | 29.72 | 67.5 | 3800 |
| 40 ft high cube equivalent unit | 2.438 | 12.192 | 2.9 | 29.72 | 86.19 | 3900 |

2.3.1. Container Building Structure

The container structure is consisted of (a) bottom structure; (b) front end frame structure; (c) backend frame structure; (d) side wall, and (f) box top structure, as illustrated in Figure 1.

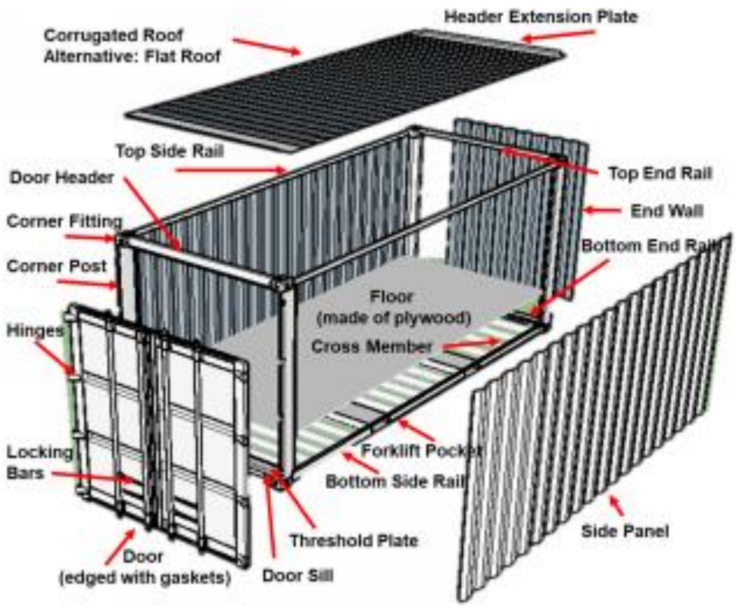
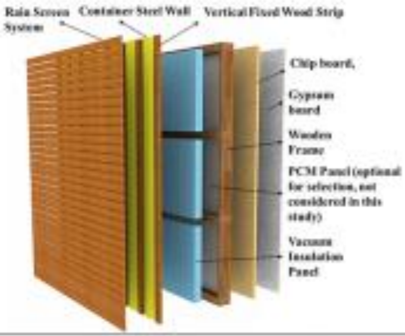



**Figure 1.** Schematic diagram of a 20 ft standard shipping container.

providing higher thermal resistance and inner space saving with respect to conventional insulation materials. Moreover, the additional use of wood strip and wooden frame can take full advantage of the limited space on the container wall bases, offer adequate protection of vacuum insulation panels, and work as the fixed framework for interior wall panels' installation.

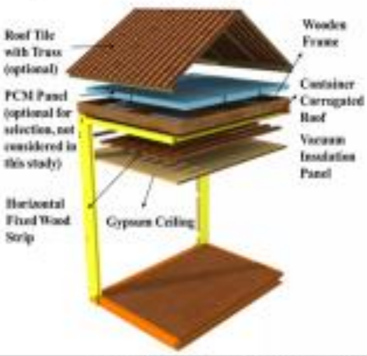



| Envelope configuration | | Thickness [mm] | Conductivity [W/(m K)] | Thermal resistance [m²K/W] | U-value [W/m²K] |
|---|---|---|---|---|---|
| Wall | Gypsum | 5 | 0.220 | 0.023 | 0.182 |
| | Chip board | 10 | 0.130 | 0.077 | |
| | VIP within wooden studs framing[1] | 60 | 0.012 | 5.000 | |
| | Container steel panel[2] | 1.6 | 42 | 0.000 | |
| | Air in 30 mm Vent. Gap | 30 | 0.160 | 0.188 | |
| | Wooden rainscreen | 30 | 0.140 | 0.214 | |
| | Total | 136.6 | | 5.501 | |

Note: 1.Wooden framing size 15mm*60mm with 610mm spacing and filling with VIP is calculated using OPAQUE 3.0. PCM technical data is from Kingston Optim-R, which taking account of an aged design value via EN 12667:2001;

2.Container steel panel is treated as flat steel sheet here, since wooden studs fill in the corrugated grooves.

**Figure 4.** Conceptual wall configuration with U-value estimation.

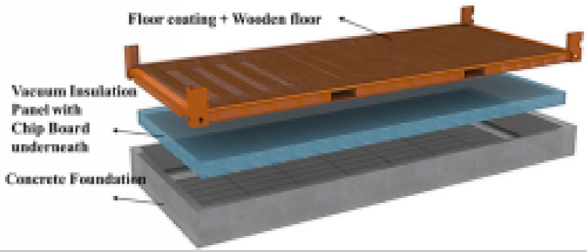



| Envelope configuration | | Thickness [mm] | Conductivity [W/(m K)] | Thermal resistance [m²K/W] | U-value [W/m²K] |
|---|---|---|---|---|---|
| Roof | Gypsum ceiling | 5 | 0.220 | 0.023 | 0.196 |
| | Chip board | 10 | 0.130 | 0.077 | |
| | VIP within wooden studs framing[1] | 60 | 0.012 | 5.000 | |
| | Container steel panel[2] | 2 | 42.000 | 0.000 | |
| | Total thickness | 77 | | 5.100 | |

Note: 1.Wooden framing size 15mm*60mm with 610mm spacing and filling with VIP is calculated using OPAQUE 3.0. PCM technical data is from Kingston Optim-R, which taking account of an aged design value via EN 12667:2001;

2.Container steel panel is treated as flat steel sheet here, since wooden studs fill in the corrugated grooves.

**Figure 5.** Conceptual roof configuration with U-value estimation.




| Envelope configuration | | Thickness [mm] | Conductivity [W/(m K)] | Thermal resistance [$m^2K/W$] | U-value [$W/m^2K$] |
|---|---|---|---|---|---|
| Floor | Floor coating | 5 | 0.18 | 0.028 | 0.193 |
| | Wooden floor | 10 | 0.13 | 0.077 | |
| | VIP within wooden studs framing[1] | 60 | 0.012 | 5.000 | |
| | Chip board | 10 | 0.13 | 0.077 | |
| | Container steel panel[2] | 2 | 42.000 | 0.000 | |
| | Total thickness | 87 | | 5.182 | |

Note: 1.Wooden framing size 15mm*60mm with 600mm spacing and filling with VIP is calculated using OPAQUE 3.0. PCM technical data is from Kingston Optim-R, which taking account of an aged design value via EN 12667:2001;

2.Container steel panel is treated as flat steel sheet here, since wooden studs fill in the corrugated grooves.

**Figure 6.** Conceptual floor configuration with U-value estimation.

### 3.2. *Methodology for Thermal Comfort Assessment*

In this section, the thermal comfort for the residential building has been assessed in Berlin (Germany), Stockholm (Sweden), and Rome (Italy), respectively. There are several reasons to choose the thermal comfort assessment. Firstly, thermal comfort is one of the major concern in living in a container building. Secondly, the indoor climate in the residential building is imperative in both psychological and physical aspects, where it could affect morale of the inhabitants, but also in its energy consumption holistically and the choices made about both envelope and structure. From another point of view, this method offers an intuitive and efficient initial assessment with graphic representations of hourly climate data compared with the time-consuming building modeling. Thermal comfort assessment is expected to help decision makers to visualize the unique overall patterns and subtle details in adaptive building design measures, characterizing different climate data during a preliminary building design or renovation process.

#### 3.2.1. Investigated Climate Datasets

With the research purposes of building performance investigation under both historical and future climate conditions, the available hourly dependent climate dataset is necessary for a dynamic simulation. The method here has the baseline, which is the typical climate data ASHRAE IWEC from 1982 to 1997 with the ".epw" format (climate file from EnergyPlus website) [34]. After that, the "CCWorldWeatherGen" tool, developed by Energy and Climate Change Division, by University of Southampton, UK, is used. The tool is used to process the "present-day" climate files of the baseline data prepared for the future climate morphing in the next stage [35]. The morphed climate data is under HadCM3 predictions for a "medium–high" emissions scenario (A2) for 2020s, 2050s, and 2080s.

#### 3.2.2. Thermal Comfort Model

The climate analysis is critical in exploring climate-adaptive potential, being an evitable part of climate-adaptive building design procedure. During the preliminary design stage, it enables a series of building design solutions that are especially devoted to human thermal comfort and energy-efficient measures. Usually, the thermal comfort characteristics are denoted with six indicators, which are air temperature, mean radiant temperature, relative humidity, air velocity in the area of environmental factors, clothing insulation, and metabolic heat in the area of personal factors [36]. In order to take

# Appendix D

## Table 1 – Pilkington **Insulight**™ Sun – Double Glazing Units

6 mm Pilkington **Optifloat**™ Clear inner pane and
16 mm argon-filled cavity, unless otherwise indicated.

### Solar control with thermal insulation (low-e)

| Product Description | Light | | Solar Radiant Heat | | | | Shading Coefficient | | U value (W/m²K) | Performance inc. acoustic Light Transmittance / g-value ($R_w$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Pane thickness combinations | | |
| Outer Pane | **Transmittance (LT) %** | Reflectance | Direct transmittance | Reflectance | Absorptance | **g-value (Total transmittance)** | Short wavelength | Total | **Argon (90%)** | 6 mm + 6 mm panes | 8 mm + 6 mm panes | 10 mm + 6 mm panes |
| Products available as Pilkington **Suncool**™, Pilkington **Suncool Optilam**™ and Pilkington **Suncool**™ Pro T (toughenable) versions, unless otherwise indicated | | | | | | | | | | | | |
| Pilkington **Suncool**™ - superior solar control with thermal insulation (low-e) | | | | | | | | | | | | |
| 6 mm 70/40 | **70** | 0.10 | 0.38 | 0.28 | 0.34 | **0.42** | 0.44 | 0.48 | **1.1** | 70/42 (31 dB) | 69/41 (36 dB) | 68/40 (40 dB) |
| 6 mm 70/35 | **69** | 0.16 | 0.34 | 0.35 | 0.31 | **0.37** | 0.39 | 0.43 | **1.0** | 69/37 (31 dB) | 68/37 (36 dB) | 67/36 (40 dB) |
| 6 mm 66/33 | **65** | 0.16 | 0.32 | 0.35 | 0.33 | **0.36** | 0.37 | 0.41 | **1.0** | 65/36 (31 dB) | 64/35 (36 dB) | 64/34 (40 dB) |
| 6 mm 60/31 | **59** | 0.11 | 0.28 | 0.32 | 0.40 | **0.32** | 0.33 | 0.37 | **1.0** | 59/32 (31 dB) | 58/31 (36 dB) | 57/31 (40 dB) |
| 6 mm Silver 50/30** | **49** | 0.39 | 0.28 | 0.43 | 0.29 | **0.31** | 0.32 | 0.36 | **1.0** | 49/31 (31 dB) | 49/31 (36 dB) | 48/30 (40 dB) |
| 6 mm Blue 50/27 | **49** | 0.19 | 0.25 | 0.35 | 0.40 | **0.28** | 0.28 | 0.32 | **1.1** | 49/28 (31 dB) | 49/28 (36 dB) | 48/27 (40 dB) |
| 6 mm 50/25 | **49** | 0.18 | 0.24 | 0.33 | 0.43 | **0.27** | 0.27 | 0.31 | **1.0** | 49/27 (31 dB) | 49/27 (36 dB) | 48/26 (40 dB) |
| 6 mm 40/22*** | **39** | 0.20 | 0.19 | 0.35 | 0.46 | **0.23** | 0.22 | 0.26 | **1.1** | 39/23 (31 dB) | 39/22 (36 dB) | 38/22 (40 dB) |
| 6 mm 30/17** | **30** | 0.25 | 0.15 | 0.37 | 0.48 | **0.18** | 0.18 | 0.21 | **1.1** | 30/18 (31 dB) | 29/18 (36 dB) | 29/18 (40 dB) |
| 6 mm 30/16*** | **29** | 0.27 | 0.15 | 0.37 | 0.48 | **0.18** | 0.17 | 0.21 | **1.1** | 29/18 (31 dB) | 29/18 (36 dB) | 28/18 (40 dB) |
| Pilkington **Suncool**™ OW* (low iron) - superior solar control with thermal insulation (low-e) | | | | | | | | | | | | |
| 6 mm 70/40 | **73** | 0.10 | 0.44 | 0.39 | 0.17 | **0.45** | 0.50 | 0.52 | **1.1** | 73/45 (31 dB) | 73/45 (36 dB) | 73/45 (40 dB) |
| 6 mm 70/35 | **73** | 0.16 | 0.38 | 0.47 | 0.15 | **0.39** | 0.43 | 0.45 | **1.0** | 73/39 (31 dB) | 73/39 (36 dB) | 72/39 (40 dB) |
| 6 mm 66/33 | **69** | 0.17 | 0.36 | 0.47 | 0.17 | **0.37** | 0.42 | 0.43 | **1.0** | 69/37 (31 dB) | 69/37 (36 dB) | 68/37 (40 dB) |
| 6 mm 60/31 | **61** | 0.11 | 0.30 | 0.32 | 0.38 | **0.32** | 0.35 | 0.37 | **1.0** | 61/32 (31 dB) | 60/31 (36 dB) | 59/31 (40 dB) |
| 6 mm Blue 50/27 | **52** | 0.20 | 0.28 | 0.46 | 0.26 | **0.29** | 0.32 | 0.33 | **1.1** | 52/29 (31 dB) | 52/29 (36 dB) | 52/29 (40 dB) |
| 6 mm 50/25 | **52** | 0.19 | 0.27 | 0.44 | 0.29 | **0.28** | 0.31 | 0.32 | **1.0** | 52/28 (31 dB) | 52/28 (36 dB) | 52/28 (40 dB) |
| 6 mm 40/22*** | **41** | 0.21 | 0.22 | 0.46 | 0.32 | **0.24** | 0.25 | 0.28 | **1.1** | 41/24 (31 dB) | 41/24 (36 dB) | 41/23 (40 dB) |
| 6 mm 30/17** | **32** | 0.27 | 0.17 | 0.50 | 0.33 | **0.19** | 0.20 | 0.22 | **1.1** | 32/19 (31 dB) | 31/19 (36 dB) | 31/19 (40 dB) |
| 6mm 30/16*** | **30** | 0.28 | 0.16 | 0.48 | 0.36 | **0.19** | 0.19 | 0.22 | **1.1** | 30/19 (31 dB) | 30/19 (36 dB) | 30/19 (40 dB) |
| Pilkington **Activ Suncool**™ (self-cleaning) - superior solar control with thermal insulation (low-e) | | | | | | | | | | | | |
| 6 mm 70/40** | **66** | 0.15 | 0.35 | 0.32 | 0.33 | **0.39** | 0.41 | 0.45 | **1.1** | 66/39 (31 dB) | 64/39 (36 dB) | 64/38 (40 dB) |
| 6 mm 70/35** | **65** | 0.21 | 0.32 | 0.44 | 0.24 | **0.35** | 0.37 | 0.40 | **1.0** | 65/35 (31 dB) | 64/35 (36 dB) | 64/34 (40 dB) |
| 6 mm 66/33** | **61** | 0.21 | 0.30 | 0.40 | 0.30 | **0.33** | 0.35 | 0.38 | **1.0** | 61/33 (31 dB) | 61/33 (36 dB) | 60/32 (40 dB) |
| 6 mm 60/31** | **56** | 0.24 | 0.27 | 0.41 | 0.32 | **0.30** | 0.31 | 0.34 | **1.0** | 56/30 (31 dB) | 55/30 (36 dB) | 54/29 (40 dB) |
| 6 mm Silver 50/30** | **47** | 0.42 | 0.27 | 0.52 | 0.21 | **0.30** | 0.31 | 0.34 | **1.0** | 47/30 (31 dB) | 47/30 (36 dB) | 46/29 (40 dB) |
| 6 mm Blue 50/27** | **47** | 0.24 | 0.23 | 0.39 | 0.38 | **0.27** | 0.27 | 0.31 | **1.1** | 47/27 (31 dB) | 46/26 (36 dB) | 46/26 (40 dB) |
| 6 mm 50/25** | **47** | 0.23 | 0.23 | 0.42 | 0.35 | **0.26** | 0.26 | 0.30 | **1.0** | 47/26 (31 dB) | 46/25 (36 dB) | 46/25 (40 dB) |
| 6 mm 30/17** | **28** | 0.30 | 0.14 | 0.40 | 0.46 | **0.17** | 0.17 | 0.20 | **1.1** | 28/17 (31 dB) | 28/17 (36 dB) | 28/17 (40 dB) |
| Pilkington **Suncool**™ One - mid-range solar control with thermal insulation (low-e) | | | | | | | | | | | | |
| 6 mm 60/40 | **59** | 0.22 | 0.35 | 0.30 | 0.35 | **0.40** | 0.41 | 0.46 | **1.0** | 59/40 (31 dB) | 58/39 (36 dB) | N/A |
| 6 mm 30/21 | **30** | 0.31 | 0.17 | 0.34 | 0.49 | **0.21** | 0.20 | 0.24 | **1.0** | 30/21 (31 dB) | 30/20 (36 dB) | 29/20 (40 dB) |

The above performance data has been determined in accordance with BS EN 410 and BS EN 673.

* With 6 mm Pilkington **Optiwhite**™ inner pane
** Annealed version only
*** Toughened version only

# Appendix E

BAUDER

## Solar PV Solutions

Our photovoltaic solutions are innovative, penetration-free systems for use in flat, green and blue roof applications.

Both our systems are extremely quick to install and provide a cost effective and highly efficient solution.



SOLAR PV SOLUTIONS

- **System manufacturer:** Bauder Limited, 70, Landseer Road, Ipswich, Suffolk, IP3 0DH. **Tel:** 01473 257 671. Fax: 01473 230 761. **Email:** technical@bauder.co.uk **Web:** www.bauder.co.uk
- **Primer type and application:** Bauder Polymer Primer, applied to the roof substrate and all upstands and skirtings. For application method and guidance information, refer clause as clause 720B.
- **Preliminary local reinforcement:** as clause 750.
- **Coating reference:** Bakor790-11 hot melt rubberised bitumen.
- **Application:** As clause 722, 760.
- **Reinforcement:** Bauder Polyester reinforcing.
- **Thickness (nominal):** 6 mm in two 3 mm coats, plus protection sheet / surfacing as described below.
- **Upstands and details:** Upstand detailing to be formed in Bakor 790-11, as clause 770A.
- **Coating protection layer to all upstands/details:** Bauder AP1, glass tissue based, modified bitumen, sand finished membrane to be used as the access layer on concealed upstand detailing. For any areas of detailing that is exposed, Bauder K4E charcoal grey slate finished membrane must be used. Installation as Clause 770C.
- **Coating protection layer:** Bauder AP1, glass tissue based, modified bitumen, sand finished membrane. Installation as Clause 780A.
- **Insulation:** 240mm thick, BauderJFRI(200) Inverted Insulation for flat roofs subject to permanent loads of up to 60KPa, to achieve the required 'U' Value – refer clause 230. This product has zero ODP and a Green guide rating of 'A+'. Installation as Clause 810A.
- **Insulation to upstands:** To all vertical upstand abutments and changes in level to be insulated, including builders kerbs (but excluding proprietary insulated integrated rooflight units), use **Bauder JFRI HP Inverted Insulation**, in combination with **60mm Bauder JFRI HP Upstand Insulation GRP facing, colour Slate Grey**, to the external face, to make up the total thickness required. Installation as clause 811B.
- **Vapour Permeable membrane:** Bauder JFRI vapour permeable membrane (loose laid). Installation as Clause 816A.
- **Surfacing:** 20-40 mm grade washed stone ballast (supplied by others), as Clause 365. Installation as Clause 820.
- **Accessories:**
- **Additional requirements:** Refer clauses 210, 310, 410, 411, 412,413, 415A, 910, 920, 930, 940.
- **Guarantee information:** 950H.

**PERFORMANCE**

**210 ROOF PERFORMANCE**

- **General:** Firmly adhered, free draining and completely weather tight.

**230 INSULATION**

- **Thermal transmittance (U-Value) of roof:** 0.15 W/m²K
- **Finished Surface:** Suitably even, stable and robust to receive roof covering.
- **Insulation compliance:** To relevant British Standard or Agrément certified.

# Appendix F

Heating | Product Information

MITSUBISHI ELECTRIC

## PUZ-HWM140VHA(-BS)

Ecodan R32

**Monobloc** Air Source Heat Pump

R32

| Key Features: | Key Benefits: |
|---|---|
| A+++ high efficiency system | Ultra low running cost |
| Compact design | Minimal installation space required |
| Maintains full heating capacity at low temperatures | Confident and quick product selection |
| Zero carbon solution | Help to tackle the climate crisis |
| MELCloud enabled | Remote control, monitoring, maintenance and technical support |

MELCloud

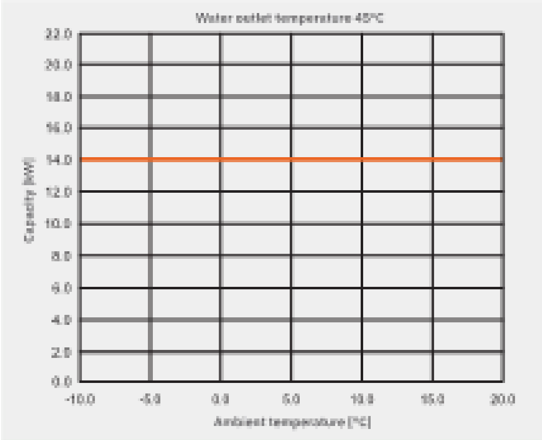

ecodan.co.uk

## Heating Product Information

**PUZ-HWM140VHA(-BS)**
Ecodan R32
Monobloc Air Source Heat Pump

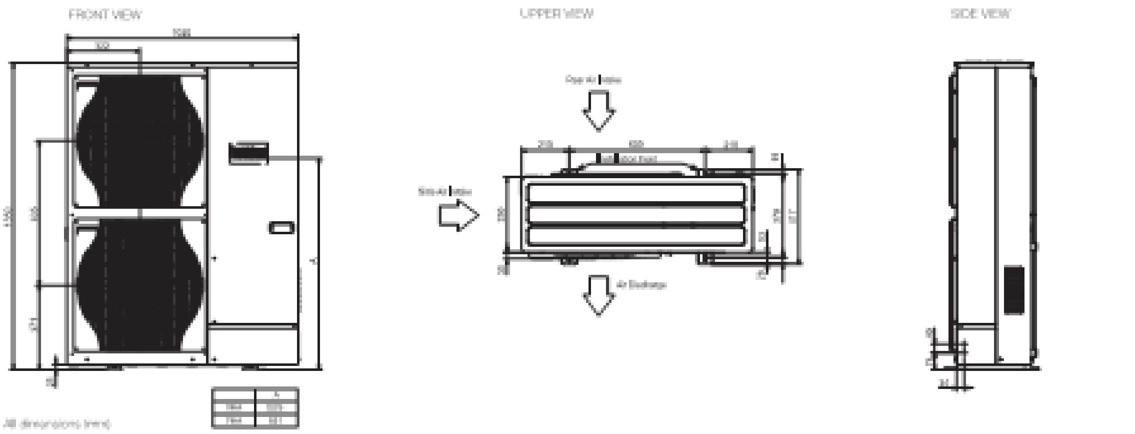
| OUTDOOR UNIT | | PUZ-HWM140VHA(-BS) |
|---|---|---|
| HEAT PUMP SPACE HEATER - 55°C | ErP Rating | A++ |
| | $\eta_s$ | 131% |
| | SCOP (MCS) | 3.35 |
| HEAT PUMP SPACE HEATER - 35°C | ErP Rating | A+++ |
| | $\eta_s$ | 176% |
| | SCOP (MCS) | 4.48 |
| HEAT PUMP COMBINATION HEATER - Large Profile *1 | ErP Rating | A+ |
| | $\eta_{wh}$ | 130% |
| HEATING *2 (A-7/W35) | Capacity (kW) | 14 |
| | Power Input (kW) | 5.71 |
| | COP | 2.45 |
| OPERATING AMBIENT TEMPERATURE (°C DB) | | -28 ~ +35 |
| SOUND DATA *3 | Pressure Level at 1m (dBA) | 53 |
| | Power Level (dBA) *4 | 67 |
| WATER DATA | Pipework Size (mm) | 28 |
| | Flow Rate (l/min) | 40.1 |
| | Water Pressure Drop (kPa) | 29 |
| DIMENSIONS (mm) | Width | 1020 |
| | Depth | 330 + 30 *7 |
| | Height | 1350 |
| WEIGHT (kg) | | 132 |
| ELECTRICAL DATA | Electrical Supply | 220-240v, 50Hz |
| | Phase | Single |
| | Nominal Running Current [MAX] (A) *5 | 18.0 [35] |
| | Fuse Rating - MCB Sizes (A) *6 | 40 |
| REFRIGERANT CHARGE (kg) / $CO_2$ EQUIVALENT (t) | R32 (GWP 675) | 3.3 |

**NOMINAL HEATING CAPACITY**




**Notes:**
*1 Combination with EHPT20X Cylinder
*2 Under normal heating conditions at outdoor temp: -7°CDB / -8°CWB, outlet water temp 35°C, inlet water temp 30°C.
*3 Under normal heating conditions at outdoor temp: 7°CDB / 6°CWB, outlet water temp 55°C, inlet water temp 47°C as tested to BS EN14511.
Low Noise mode accessory (reference PAC-SA03TA-EPI available for VHA chassis.
*4 Sound power level tested to BS EN12102.
*5 Under nominal heating conditions at outdoor temp: 7°C, outlet water temp: 35°C.
*6 MCB Sizes BS EN60898-2 & BS EN60947-2.
*7 Grille
$\eta_s$ is the seasonal space heating energy efficiency (SSHEE) $\eta_{wh}$ is the water heating energy efficiency

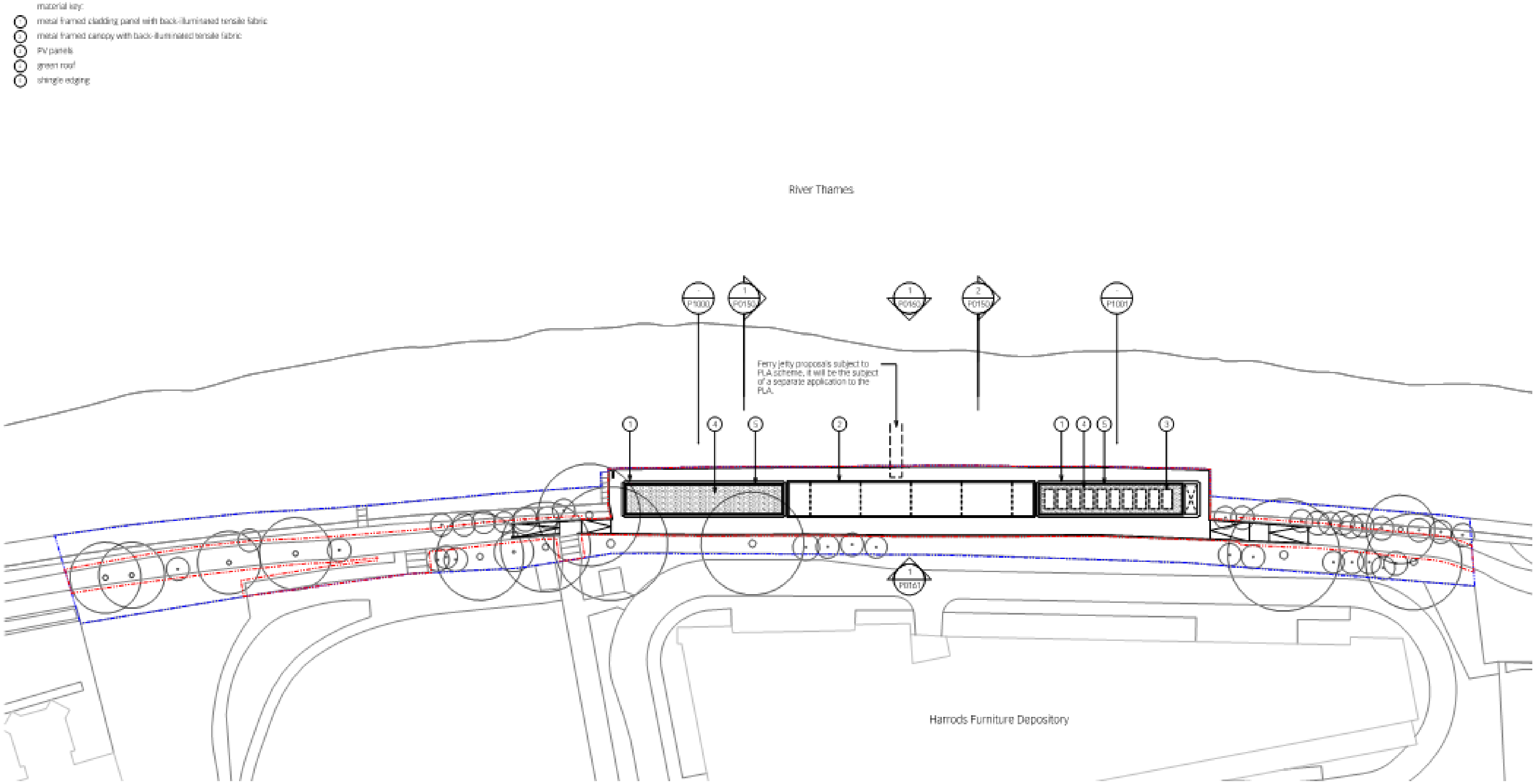
**PUZ-HWM140VHA(-BS)** DIMENSIONS




All dimensions (mm)

| Flow Temperature | QUHZ-W40VA | PUZ-WM50VHA | PUZ-WM60VAA | PUZ-WM85VAA | PUZ-WM112VAA | PUZ-HWM140VHA | PUZ-HWM140YHA |
|---|---|---|---|---|---|---|---|
| 35 | 3.63 | 4.57 | 4.76 | 4.79 | 4.78 | 4.34 | 4.30 |
| 36 | 3.59 | 4.50 | 4.69 | 4.72 | 4.70 | 4.28 | 4.25 |
| 37 | 3.56 | 4.44 | 4.61 | 4.66 | 4.62 | 4.23 | 4.19 |
| 38 | 3.52 | 4.37 | 4.54 | 4.59 | 4.54 | 4.17 | 4.14 |
| 39 | 3.49 | 4.30 | 4.47 | 4.52 | 4.47 | 4.11 | 4.08 |
| 40 | 3.45 | 4.23 | 4.40 | 4.45 | 4.39 | 4.05 | 4.02 |
| 41 | 3.42 | 4.17 | 4.33 | 4.38 | 4.31 | 4.00 | 3.97 |
| 42 | 3.39 | 4.10 | 4.25 | 4.31 | 4.23 | 3.94 | 3.91 |
| 43 | 3.35 | 4.03 | 4.18 | 4.25 | 4.15 | 3.88 | 3.85 |
| 44 | 3.32 | 3.96 | 4.11 | 4.18 | 4.07 | 3.83 | 3.80 |
| 45 | 3.28 | 3.90 | 4.04 | 4.11 | 3.99 | 3.77 | 3.74 |
| 46 | 3.25 | 3.83 | 3.99 | 4.05 | 3.93 | 3.72 | 3.69 |
| 47 | 3.21 | 3.76 | 3.94 | 3.98 | 3.86 | 3.67 | 3.64 |
| 48 | 3.17 | 3.69 | 3.89 | 3.92 | 3.80 | 3.62 | 3.59 |
| 49 | 3.13 | 3.63 | 3.85 | 3.85 | 3.73 | 3.57 | 3.54 |
| 50 | 3.10 | 3.56 | 3.80 | 3.79 | 3.67 | 3.52 | 3.49 |
| 51 | 3.06 | 3.49 | 3.75 | 3.73 | 3.60 | 3.46 | 3.44 |
| 52 | 3.02 | 3.43 | 3.70 | 3.66 | 3.54 | 3.41 | 3.39 |
| 53 | 2.98 | 3.36 | 3.65 | 3.60 | 3.47 | 3.36 | 3.34 |
| 54 | 2.94 | 3.29 | 3.61 | 3.53 | 3.41 | 3.31 | 3.29 |
| 55 | 2.91 | 3.22 | 3.56 | 3.47 | 3.34 | 3.26 | 3.24 |

# Appendix G


material key:
1 metal framed cladding panel with back-illuminated tensile fabric
2 metal framed canopy with back-illuminated tensile fabric
3 PV panels
4 green roof
5 shingle edging
River Thames
P1000
P0150
P0160
P1001
Ferry jetty proposals subject to PLA scheme, it will be the subject of a separate application to the PLA.
P0161
Harrods Furniture Depository